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COMMONWEALTH OF AUSTRALIA.

Commonwealth Scientific and Industrial Research Organization.

FIRST ANNUAL REPORT FOR THE YEAR ENDING 30TH JUNE, 1949.

I. INTRODUCTORY.

1. General.

The Commonwealth Scientific and Industrial Research Organization was established on 19th May, 1949, when the *Science and Industry Research Act* 1949 was proclaimed. Under that Act the Organization took the place of the existing Council for Scientific and Industrial Research, which in turn had in 1926 taken the place of the former Institute of Science and Industry.

The powers and functions of the Organization are similar to those of the Council and include the initiation and carrying out of research in connexion with, or for the promotion of, primary and secondary industries in the Commonwealth or any Territory of the Commonwealth, or in connexion with any matter referred to the Organization by the Minister; the training of research workers; the making of grants in aid of pure scientific research; the testing and standardization of scientific apparatus and instruments, and the carrying out of scientific investigations connected with standardization; the collection and dissemination of information relating to scientific and technical matters; the publication of scientific and technical reports and periodicals; and acting as a means of liaison with other countries in matters of scientific research.

There has been a major change in administrative responsibility, since the governing body of the Organization is an Executive of five persons rather than a large Council. The Executive will be assisted by an Advisory Council constituted in precisely the same way as the former C.S.I.R.

It is hoped that early action will be taken to issue regulations to permit the re-establishment of State Committees and through them the formation of the Advisory Council.

The Organization is carrying on the work of the Council for Scientific and Industrial Research without any break, and the present report deals with the researches undertaken during the year ended 30th June, 1949, without reference to the change in organizational structure which occurred on 19th May, 1949. Text references to earlier reports relate to the Annual Reports of the Council, the last of which is the 22nd Annual Report for the year ending 30th June, 1948.

2. Executive.

As at present constituted the Executive of the Organization consists of the following:—Dr. I. Clunies Ross (Chairman), Dr. F. W. G. White (Chief Executive Officer), Dr. S. H. Bastow, Mr. D. A. Mountjoy (part-time), and Mr. H. J. Goodes (part-time).

3. Retirement of Sir David Rivett and Dr. A. E. V. Richardson.

In announcing the formation of the Organization its Minister (the Hon. J. J. Dedman) recorded, on behalf of the Prime Minister and the Government of the Commonwealth, the substantial debt owed not only by the Government but by the community as a whole to Sir David Rivett and Dr. A. E. V. Richardson, both of whom had reached the retiring age.

He pointed out that Sir David, as Chief Executive Officer of the C.S.I.R. for just on twenty years and more recently as Chairman, had become identified not only with the Council which, with its successor body, would always stand as a monument to his untiring care and wise direction, but with Australian science in general. Sir David had seen the Council grow from small and uncertain beginnings to a great organization of truly national proportions with an international reputation. On his retirement, he would have the satisfaction of knowing that he carried with him the affection of his thousands of colleagues, the esteem of the whole community, and the gratitude of the Government and Parliament of the Commonwealth.

Dr. Richardson, first as a member of the Executive Committee of C.S.I.R., later as Deputy Chief Executive Officer, and finally as Chief Executive Officer, had brought to the Council an unrivalled knowledge of the problems of Australian agriculture, and a wide experience and sound judgment which had influenced all the Council's activities. He had played a major part in the development of the Council's work in the plant and animal industries, than which none had yielded results of greater value to the Commonwealth. As Dean of the Faculty of Agriculture in the University of Melbourne, as first Director and creator of the Waite Agricultural Research Institute in South Australia, and as Chief Executive Officer of C.S.I.R., Dr. Richardson's name would always be associated with the development of Australian agricultural science, to which he had given a lifetime of devoted service.

4. Transfer of Division of Aeronautics.

Following the enactment of the *Public Service Act (No. 2)* 1948 the Division of Aeronautics was transferred to the Department of Supply and Development in February, 1949.

5. The Development of North Australia.

Much of the intensive agricultural development in Australia has occurred in the coastal fringe of eastern, southern, and western Australia. It is generally agreed that the major agricultural development of the future will be in northern Australia, particularly in Queensland, and C.S.I.R.O. has an important function to assist in surveying and advising on projects connected with this. It is important, not only to Australia from the economic aspect, but also as a contribution to the solution of the world's major social problem, the provision of adequate food supplies.

World food shortage of protein, and in particular the need of the United Kingdom for meat, emphasize the vital and immediate necessity for the stimulation of the beef cattle industry, the present main industry of northern Australia. Recent conferences between the Australian Meat Board, the Queensland Department of Agriculture and Stock, and C.S.I.R.O. have outlined plans for detailed work, particularly on the improvement of the cattle pastures of Queensland and for the development and study of existing and new cattle breeds more suited to the north. To that end two new stations are envisaged, one in southern Queensland to study primarily cattle pastures, and the other north of Rockhampton to work on cattle breeding and feeding problems.

An interesting new development is also taking place in the Burdekin River region of Queensland. The Queensland State Bureau of Investigation is undertaking the engineering aspects involved in the building of a large capacity dam on the Burdekin River, while C.S.I.R.O. is working in conjunction with the State Department of Agriculture and Stock on the agricultural aspects of crops and pasture production in the irrigable areas commanded by the proposed reservoir.

An intensive study is under way in the development of suitable irrigated pastures for the region, with the object of utilizing such pastures for fattening beef cattle. The efforts of the Organization's officers in the growing of high-quality tobacco under irrigation have achieved some measure of success. The setting up of a highly productive tobacco industry in this area would be of considerable economic value to Australia, because of the present shortage of dollars.

The work of the Reconnaissance Survey party in other areas of northern Australia has been described in prevous reports. These surveys are being continued, and work on the Barkly Tableland was undertaken during the past year.

Investigation of the potentialities of northern Australia has not been restricted to agricultural development, since the Organization is also co-operating with the Queensland Government in a programme of work on pearl shell and the pearl oyster. A station has been established on Thursday Island at which research on oyster culture will be conducted. From this base a research vessel of the Division of Fisheries will conduct surveys along the northern coasts, with the object of defining present occurrences of marketable fish.

6. Wool Production and Textile Research.

The major activities associated with the programme of biological research in the field of wool production are reported in Chapter VII. This work is carried out mainly in the Divisions of Animal Health and Production, Biochemistry and General Nutrition, and Plant Industry. The main difficulties facing the development of the programme of wool research are those associated with the provision of suitable buildings and field stations.

Work on wool textiles is reviewed in Chapter XIV. This is being carried out in certain of the Divisions, e.g. the Division of Industrial Chemistry and the Division of Physics, and at Geelong, where a Wool Textile Research Laboratory has been established. The work at this centre is done in close association with the Textile College of the Gordon Institute of Technology, to the Council of which grateful acknowledgment is due from the Organization for its ready assistance in the provision of laboratory and office accommodation and for its general co-operation and interest. Separate laboratories for wool textile research, which will continue to maintain close contact with the Gordon Institute, are being erected at Belmont, Geelong.

7. Fuel Research.

Reference was made in the previous Report to the establishment of a Coal Survey Section to carry out a comprehensive survey of the physical and chemical properties of Australian coals. The section has now been renamed the "Coal Research Section" and a site for its head-quarters laboratory is being acquired at North Ryde, Sydney, adjacent to the Commonwealth Experimental Building Station. It is hoped to make a start shortly on the erection of laboratories. A considerable amount of equipment for the section has been ordered. One of the main difficulties it is experiencing, apart from that of obtaining laboratory buildings, is the shortage in Australia of suitably trained and experienced staff. However, it has been possible to recruit a number of experienced workers overseas who will form a nucleus from which the remainder of the Section can develop.

8. Wild Life Survey.

The Organization has often been asked by primary producers' representatives to study the possibility of developing new methods of rabbit control. It was considered that the most useful approach to the problem would be a comprehensive biological investigation having the following general objectives:—(*a*) the acquisition of detailed knowledge of rabbit ecology (distribution, reproduction and rate of increase, movements, feeding habits, natural controls, &c.) under the variety of conditions obtaining in this continent—information that is essential for the development of a proper strategy of control, for the assessment of the true importance of the rabbit in the national economy, and to point a way to developing new methods of dealing with it; and (*b*) to obtain a better understanding of the value and limitations of standard control methods, and to determine whether the efficiency of any of them could be increased. As the rabbit investigation does not fall naturally within the scope of any existing Division or Section of the Organization, a Wild Life Survey Section was established early in 1949 to handle it and any other problem relating to native or introduced mammals or birds that might merit study because of its economic or national importance. A senior member of the staff of the Division of Entomology, with experience in field ecology and mammal pest problems, has been appointed Officer-in-Charge of the Section.

9. Building Projects.

One of the greatest difficulties being faced by the Organization in the prosecution of its research programme is the lack of suitable buildings and the extreme slowness with which they can be provided. The work of many Divisions is already being carried on under crowded and difficult conditions and in many cases proposed new research programmes are held up through lack of accommodation. Among the major building projects contemplated are the provision of a central block at Canberra to provide a library and other facilities for the Divisions of Plant Industry and Entomology, the Wool Biological Laboratory at Prospect, New South Wales, the Wool Textile Research Laboratory at Geelong, the laboratory building for the Division of Tribophysics in the grounds of the University of Melbourne, and the Biochemistry block for the Division of Industrial Chemistry at Fishermen's Bend, Victoria. This latter building will house certain lines of the wool textile research work. During the year under review the new building for the Division of Biochemistry and General Nutrition and the Section of Mathematical Statistics in the grounds of the University of Adelaide has been practically completed.

10. Visit of Indian Scientific Delegation.

The visit of the Australian Goodwill Scientific Delegation to India was mentioned in the previous Report. During the year under review an Indian Scientific Delegation returned the visit to Australia. It consisted of Dr. S. Krishna, Director of Research at the Forest Products Research Institute, Dehra Dun, Lieutenant-Colonel M. L. Ahuja, Director of the Central Research Institute, Kasauli, Dr. B. P. Pal, Director of the Indian Agricultural Research Institute, New Delhi, and Mr. V. P. Sondhi, Deputy Director, Geological Survey of India. The visitors spent six weeks in Australia, arriving at the end of February, 1949. During their stay they visited all States and saw most of the Organization's Laboratories as well as the Universities, Commonwealth and State Government laboratories, and some of the larger industrial undertakings.

11. OVERSEAS VISITORS.

As mentioned elsewhere in this Report the Organization is aware of the importance of keeping its research workers in close touch with new developments overseas, and for this purpose sends abroad a number of its officers to study at research institutes and to meet leading experts in their own field. Until fairly recently this has been a one-way traffic, but it is pleasing to note that a considerable flow of visitors in the reverse direction now appears to be commencing. A number of leading scientists from overseas have visited Australia during the year under review. Not all of these have come under the auspices of C.S.I.R.O., but most of them have been keen to see the work of the Organization and to visit its laboratories. C.S.I.R.O. officers have received much stimulus and help by such visits. Professor J. L. Lush, Professor of Animal Breeding at the Iowa State College of Agriculture, United States of America, and an expert in plant and animal genetics, spent three months in Australia at the invitation of the Organization. The report which he submitted on the needs for research in genetics in Australia is at present under consideration. Professor Z. I. Kertesz, Professor of Chemistry at the State Agricultural Experiment Station, Cornell University, United States of America, spent nine months in Australia as a guest of the Royal Australian Chemical Institute, the Australian Food Technology Association, and the Organization. He spent some of this time in the laboratories of the Division of Food Preservation and Transport and gave a number of lectures in Australia on the chemistry of fruit and vegetables and their products. Dr. E. H. Callow, of the Low Temperature Research Station, Cambridge, and Mr. N. E. Holmes, of the United Kingdom Ministry of Food, visited Australia to discuss a programme of research on the eating quality of frozen beef. Sir Henry Tizard, Chairman of the United Kingdom Advisory Committee on Scientific Policy, visited Australia at the invitation of the Commonwealth Government, and spent a considerable time seeing the work of the Organization's Laboratories. Among visitors sponsored by the Australian National University were Professor M. L. Oliphant, Professor of Physics, University of Birmingham, Sir Geoffrey Taylor, Yarrow Research Professor of the Royal Society, and Sir Norman Howarth, formerly Professor of Chemistry at the University of Birmingham.

Following the Seventh Pacific Science Congress a number of delegates came to Australia from New Zealand to visit the Organization's Laboratories. These included Dr. Wang Ching-Hsi, Senior Counsellor, U.N.E.S.C.O. Natural Sciences Department, Dr. E. S. Archibald, Dominion Agricultural Experiment Station, Canada, Professor T. M. W. Cameron, Director of the Institute of Parasitology, McGill University, Canada, Dr. W. H. Cook, National Research Council, Canada, Dr. E. C. Kellogg, United States Department of Agriculture, Professor H. S. Smith, Department of Entomology, University of California, Dr. W. E. Van Steenburgh, Department of Agriculture, Canada, Professor G. W. Robinson, Department of Agricultural Chemistry, University of North Wales.

12. OVERSEAS CONFERENCES.

During the year a number of important scientific conferences held overseas were attended by officers of the C.S.I.R.O. These included the Seventh International Congress for Entomology in Sweden; the Fourth Imperial Mycological Conference, London; the Fifth Imperial Entomological Conference, London; the Eighth International Congress for Genetics, Sweden; the International Congress on the Physiopathology of the Reproduction of Animals, held in Italy. The First Meeting of the Indo-Pacific Fisheries Council, established by the F.A.O., was held in Singapore in March, 1949, and was attended by Dr. H. Thompson, Chief of the Division of Fisheries. Five senior officers of the Organization attended the Seventh Pacific Science Congress held in New Zealand.

13. STUDENTSHIPS.

Previous reports have outlined the Organization's scheme for sending officers overseas to collect information on new developments in scientific research and to acquire general experience in research and a training in new techniques. On 30th June, 1949, seventeen officers were abroad. In addition, a number of studentships have been created with the object of training more recent graduates in fields which would enable them to fill specific posts in the Organization on completion of their training abroad. During the year under review, twelve studentships were awarded from general C.S.I.R.O. funds, in addition to four for work on wool and one from S.I.E.F. moneys. The studentships are tenable for a period of two years and at the close of the year 32 holders of studentships awarded in previous years were receiving training in laboratories in the United Kingdom and five in the United States.

14. AUSTRALIAN LEATHER RESEARCH ASSOCIATION.

The Organization has continued to support the Australian Leather Research Association. This body, which has the legal form of a non-profit-making company registered under the New South Wales Companies Act, is similar to the research associations operating in Great Britain under the aegis of the Department of Scientific and Industrial Research. A Director of Research is shortly to arrive from Great Britain and work is proceeding on the equipment of laboratories at Lane Cove, Sydney.

15. COLLABORATION WITH THE UNIVERSITIES.

The Organization gratefully acknowledges its debt to the various Australian universities with which it works in close collaboration. The establishment of research units within the universities is of great importance as it enables the research workers to enjoy the stimulus and help of authorities in different fields of science. C.S.I.R.O. work in the various universities has now grown considerably and is mentioned in the main body of the Report. In the University of Sydney the National Standards Laboratory, the Radiophysics Laboratory, and the McMaster Laboratory of the Division of Animal Health and Production, are all accommodated in the grounds of the University. The Radio Research Board and Mathematical Instruments Section are also housed in the Department of Electrical Engineering. The University of Melbourne provides accommodation for the Division of Tribophysics in the Chemistry School and it is hoped shortly to begin the erection of a separate laboratory building for this Division within the University grounds. The head-quarters of the Division of Animal Health and Production in Melbourne are located in the grounds of the Veterinary Research Institute. In Adelaide the Division of Biochemistry and General Nutrition has its main laboratories in the University grounds and the Division of Soils is housed by the Waite Agricultural Research Institute. The Section of Mathematical Statistics is also accommodated in the University. The Plant and Soils Regional Laboratory in Queensland is accommodated by the University at St. Lucia. Various co-operative investigations are also being carried out in the universities of Western Australia and Tasmania.

16. Finance.

Chapter XXX. of this Report gives details of expenditure by the Organization totalling £1,931,785. Of this total £142,206 was contributed other than directly from the Commonwealth Treasury and this amount included £52,570 expended from the Wool Industry Fund. In addition, the sum of £186,285 was expended on wool and textile research from funds derived as a result of the passing of the *Wool Use Promotion Act* 1945. Certain other expenditure involved in erection costs of buildings was also incurred on behalf of the Organization. The Organization is particularly gratified with the way in which outside bodies continue to support it, and with the marked interest evinced by certain sections of industry which have provided donations for co-operative research. Among the many contributions received reference may be made to those of the Commonwealth Bank, the Australian Dairy Cattle Research Association, the New South Wales Department of Agriculture, the New South Wales Water Conservation and Irrigation Commission, the Cement and Concrete Manufacturers' Association, the Queensland Meat Industry Board, the National Gas Association, the Dried Fruits Control Board, the timber industry, and the pulp and paper industry.

17. Organization.

For the purpose of carrying out its research work the Organization has established a number of Divisions and Sections. The Divisions, of which there are now fourteen, comprise the major establishments, which may be further sub-divided into Sections; there are also independent Sections comprising establishments which have not reached a stage of development, so far as the scope and magnitude of their operations are concerned, to justify their designation as Divisions.

In the present Report an attempt has been made to group the material according to its subject-matter rather than (as in the past) according to the Division or Section concerned. Additional chapters and appropriate cross references have been inserted, however, to permit the work of any particular Division to be reviewed as a whole.

As the Organization's investigations extend on a Commonwealth-wide basis, and as many of the investigations which are being conducted—particularly those concerned with problems affecting the agricultural and pastoral industries—necessitate experimental work in the field, a number of branch laboratories and field stations have been established in various parts of Australia.

The Divisions which have been established (in order of their formation) are as follows:—

Plant Industry, with head-quarters and main laboratories at Canberra, branch laboratories at Brisbane, Lawes, Queensland, and field stations and experiment farms at Stanthorpe, Queensland, Kojonup, Western Australia, Trangie, New South Wales, and the Ord River, Western Australia.

Entomology, with main laboratories at Canberra and field stations at Bright, Victoria, and Trangie, New South Wales.

Animal Health and Production, with head-quarters in Melbourne and main laboratories in Melbourne and Sydney, a branch laboratory at Yeerongpilly, Queensland, and field stations at Badgery's Creek, New South Wales, Barooga, New South Wales, Cunnamulla, Queensland, and Werribee, Tooradin and Coleraine, Victoria.

Biochemistry and General Nutrition, with main laboratories at Adelaide and field stations at O'Halloran's Hill and Robe, South Australia.

Soils, with laboratories at Adelaide.

Forest Products, in Melbourne.

Food Preservation and Transport, with head-quarters and main laboratories at Sydney, branch laboratories in Brisbane, and minor laboratories at Gosford, New South Wales.

Fisheries, with main laboratories at Cronulla, New South Wales, and an exploration section at Perth and field stations at Brisbane, Thursday Island and Hobart.

Metrology, Physics and Electrotechnology, comprising together the National Standards Laboratory, Sydney.

Radiophysics, at Sydney.

Industrial Chemistry, with head-quarters and main laboratories in Melbourne.

Tribophysics, in Melbourne.

The following are the Sections:—

Irrigation Research Station (*Murray Irrigation Areas*), Merbein, Victoria.

Irrigation Research Station (*Murrumbidgee Irrigation Areas*), Griffith, New South Wales.

Ore Dressing Investigations, Melbourne and Kalgoorlie.

Mineragraphic Investigations, Melbourne.

Mathematical Statistics, Adelaide.

Dairy Research, Melbourne.

Building Research, Melbourne.

Meteorological Physics, Melbourne.

Coal Research, Sydney.

Wild Life Survey, Canberra.

Wool Textile Research, Geelong.

In addition, Regional Centres (co-operative research units staffed with officers from the appropriate specialist Divisions to attack the problems of a particular district) have been established as follows:—

Regional Pastoral Laboratory, Deniliquin, with its associated Falkiner Memorial Field Station.

Regional Pastoral Laboratory, Armidale, with its associated field station, "Chiswick".

Tasmanian Regional Laboratory, Hobart.

Western Australian Regional Laboratory, Perth.

Plant and Soils Laboratory, Brisbane.

II. SOILS.

1. General.

The national importance of studies of the soil as a solid foundation for proper land use needs no emphasis. The intensification of farming under irrigation or by pasture development and the solution of problems of soil erosion and conservation must stem from soil research.

The Organization's work in this field is undertaken by its Division of Soils with head-quarters at the Waite Agricultural Research Institute of the University of Adelaide. Some work on soils and their behaviour under irrigation is being undertaken at the Commonwealth Research Station (Murray Irrigation Areas), Merbein, and at the Irrigation Research Station (Murrumbidgee Irrigation Areas), Griffith (*see* Chapter IV., Sections 2 (*a*) and (*b*) and 3 (*a*)–(*c*)).

Division of Soils.—The work of this Division is described in this Chapter.

The programme of investigations has moved forward steadily during the past year, although hampered considerably by shortage of trained staff, in consequence of which the field work has progressed more slowly and many requests for assistance from other agencies have not been met. The Division's commitments in land settlement schemes have largely been fulfilled although there are still requests for examination or survey, particularly in Western Australia, South Australia and New South Wales. Projects in association with the Departments of Agriculture in Victoria, South Australia and Queensland are under way.

The major soil surveys undertaken have been in North Australia on the Barkly Tableland, South Australia, in the northern marginal lands and Kangaroo

Island, Western Australia, in the Albany district, New South Wales in the Macquarie district, the Hunter Valley, the Lismore district, and the Riverina, and Queensland in the Burdekin Valley. As indicated in the last annual report, the attention of the Division is turning in field work towards broader scale rather than intensive surveys. One of its principal duties is seen as a summing up of the soil resources of Australia and the reconnaissance and broader type of survey is the only practicable method of obtaining results in reasonable time. Each of the five regional centres aims at preparing a new map of soil resources in its sphere of action which may later be co-ordinated into a large-scale map of agricultural regions of Australia.

A step forward in building up the regional centres was taken at Perth and Hobart during the year by the appointment of staff for research in soil chemistry and routine analysis of survey samples. Small laboratories have been partly fitted out and should be in working condition in the near future. They are designed to deal with soil samples and problems requiring chemical examination within the specific region, thus relieving pressure on the Adelaide laboratories. The Perth laboratory is in the Institute of Agriculture at the University and that at Hobart in the C.S.I.R.O. building, "Stowell". A chemist and physicist are available for a laboratory at Brisbane which, it is expected, will be occupied at the end of 1949.

Close liaison has been maintained with the University of Adelaide, through the Waite Agricultural Research Institute at which the Division has its head-quarters, and with all State Departments of Agriculture, Lands, Irrigation and Soil Conservation.

Four officers were overseas during the year, either working in British laboratories or making observations in their special fields.

A new series of publications entitled "Soil and Land Use Reports" was begun to facilitate the application in practice of data arising from pedological and soil survey work.

2. Soil Survey and Pedology.

Limits to the scope and number of projects undertaken were set by the available staff, but twelve areas varying in sizes from 2 to 30,000 square miles were surveyed in degrees of completeness ranging from highly detailed to broad reconnaissance form.

(*a*) *South Australia.*—An area about 55,000 acres in the Hundred of Duncan, Kangaroo Island, was surveyed in 1948. It is the second portion of the large area of Crown Land on the island which it is proposed to open for settlement. The soils pattern is similar to that of the earlier survey though the soils vary in detail and the ironstone gravel in the soils becomes heavier towards the west. The gravelly and massive ironstone may affect extensions later in that direction.

A field survey was recently begun of the interesting group of soils under intensive development in the Barossa District of South Australia, on which occur problems of erosion and infertility. It will probably continue all next year.

The examination of the Northern Marginal Lands area which commenced in 1946 was finished in 1948. The work, which involved reconnaissance over a large and detail over a smaller area, concentrated on three Hundreds of Willochra, Coonatto and Pinda, east and north of Quorn in the Willochra Valley. Considerable detail was obtained on erosion, land use, and soil types. The soils are of interest in showing the transition from the superior red brown earths growing wheat, with a rainfall of 14 inches and over, on the west side, to the drier and more saline conditions within a few miles to the east.

Close studies have been made of several areas in the Murray Valley for horticultural development, principally at Loxton and Renmark, where the design of fruit blocks has been tied very closely to variations in soil type.

(*b*) *Victoria.*—A concluding visit was paid to the Coleraine area to complete the collection of field data for the survey. The data now available from field and laboratory sources allow a better classification of the soils and provide a rational explanation of the gullying and hillside slumping characteristic of the area. The soil map and a general report on the practical aspects of conservation have been prepared.

Work was resumed after an interval of nearly four years on the Nathalia portion of the Murray Valley Irrigation Area. This area is in course of engineering development and the aim is to supply the design and construction engineers with data on the soils that may affect channel reticulation and capacities. The settlement of a further 60,000 acres intensively under a post-war scheme is actively under way.

(*c*) *New South Wales.*—The irrigation zone in the Riverina region has been one main centre of activity. Detailed survey on the Deniboota Irrigation District proceeded during 1948 up to the stage when about 200,000 acres had been covered. The balance of 100,000 acres was surveyed on a moderately broad scale and will be dealt with in detail as opportunity offers before irrigation is installed in several years' time. A considerable number of properties, mostly on the Berriquin Irrigation District, involving an area of 20,000 acres, were surveyed before resumption for closer settlement. The policy is to report on all such estates on offer to the Government for soldier settlement subdivision.

Broad reconnaissance of the soils of the irrigation zone in Victoria, including portions of the Goulburn Valley and Loddon Valley, and in New South Wales the Denimein Irrigation District, Jerilderie Shire, Jernargo Irrigation District, Murrakool Irrigation District, and part of Murrumbidgee Irrigation Areas, was made. The total area now covered amounts to 18,000 square miles in the region.

One of the largest units for survey undertaken by the Division was the Macquarie Region, embracing the valleys of the Bogan and Macquarie Rivers and aggregating 30,000 square miles in extent. A reconnaissance of this was completed in 1948 and more detailed examination is now under way of certain portions with a proposed value for irrigation. An aerial photographic survey was made of part of the area and will be invaluable in the final mapping. The work is to continue for another season at least, particularly as this is a most interesting area from the point of view of soil and potentiality for further development as well as for soil conservation plans.

The Hunter Valley survey was completed over the project area of 250 square miles north and south of Muswellbrook which was commenced in 1947. Mineralogical studies have been begun on the derivation of the soils and the related geological formation.

Work on the Southern Tableland region radiating from Canberra has been begun but is mainly held up by the demands of the Macquarie region survey. Aerial photographs are being used for this reconnaissance survey. A number of minor investigations have been undertaken for the Department of the Interior in the Australian Capital Territory.

Field work continued on the basaltic soils of the Lismore district as both a broad-scale and a detailed survey through 1948 and is now approaching completion. The survey and allied laboratory work mentioned elsewhere form part of a project being attacked by C.S.I.R.O. and the New South Wales Department of Agriculture in co-operation.

(*d*) *Queensland.*—The establishment of the regional soils organization at Brisbane mentioned in the last annual report was the first step in a broad investigation of Queensland soils. The initial project was the examination of the potentiality of the Burdekin Valley soils that might be commanded by a proposed dam on the river. The reconnaissance of the area was commenced in 1948 and resumed in the winter of 1949. Progress was slower than anticipated owing to severe field working conditions, but a satisfactory stage was reached and a preliminary report prepared. An area of 15,000 acres of levee soils was surveyed in moderate detail to determine its general suitability for tobacco culture, and selected units were defined for development. The main survey was resumed in May, 1949.

(*e*) *Western Australia.*—Field parties have been active during the 1948-49 summer in the Albany district, using the system employed in previous years of making detailed spot surveys of limited areas to characterize soil associations and then linking them over very much larger stretches of country by broader surveys. The area extended from Denmark to Albany to Many Peaks along the south coast and north to Lake Muir and Mount Barker. A total of 3,684 square miles was mapped in the district and the area linked to earlier soil surveys to the north.

Further examinations were made of estates offered to the Government for closer settlement of servicemen and reports were prepared for the appropriate authority on the soil and potentiality features.

(*f*) *North Australia.*—The North Australia Survey, which is a joint responsibility of the Divisions of Plant Industry and Soils, continued its work. The Barkly Tableland survey was completed in August, 1948. This large area, extending from the Gulf of Carpentaria to the central desert region, from north-western Queensland to the overland highway to Darwin, has a wide variety of soils which under the range of climate from wet coastal to arid inland types governs the agricultural potential, in this case beef cattle raising. The survey occupied two seasons in the field and the report summarizing the observations and data collected is being completed.

The North Australian survey party left in May for the Victoria River Downs region for the current season's work, which will link with the 1946 survey towards Katherine on the east and the Ord River survey carried out by the Western Australian Department of Agriculture in 1944 on the west. Aerial photographs of the whole area were made for the survey by the Royal Australian Air Force and base plans were prepared by the Department of the Interior. It is anticipated that the survey on the Victoria River Downs area will continue for a second season in 1950.

(*g*) *Tasmania.*—Owing to re-arrangement of staff, no work was possible in Tasmania during the latter half of 1948. Some preliminary inspections and minor surveys of areas proposed for or being developed for settlement of servicemen on King and Flinders Islands were made in 1949 but it has not been practicable as yet to resume a full programme. This is planned for the summer of 1949-50 with additional staff.

3. SOIL CHEMISTRY.

Chemical investigations have been continued on the soil samples collected during the field survey of the Northern Rivers District of New South Wales. Attention has been concentrated on soils of the red loam types, but other types in the survey area have also been studied. In addition to the routine chemical description of the type profiles, detailed studies have been made of the variability in soil reaction, exchangeable cations, organic carbon, nitrogen, and phosphate in selected samples from the grid surveys. Much information has been obtained on the cation exchange capacity of these soils and supplemented by means of titration curves of characteristic soils.

Investigations into possible seasonal trends in soil reaction at Barooga (New South Wales) have been completed and the results are being analysed. It is apparent that the variability in soil reaction from spot to spot, even within a relatively small area of a few square feet, is greater than any seasonal change. The changes in reaction from spot to spot in an apparently uniform area of soil are associated not only with variations in the proportion of exchangeable hydrogen to exchangeable metal ions, but also with variations in the exchange capacity of the soils. Parallel observations at the Waite Agricultural Research Institute are still in progress.

Factors controlling availability of trace elements in soils have continued to receive attention and preliminary work has been carried out on methods designed to fractionate the copper and manganese in certain soils. As part of the earlier work designed to assist in the study of toxaemic jaundice, determinations have been made of the amounts of copper and molybdenum taken up by subterranean clover pastures at different stages of growth. Monthly samplings showed only minor changes in the amounts of copper throughout the season. There was, however, a steady decline in the proportion of molybdenum in the plant as maturity was approached.

Continued progress has been made in the development of improved spectrochemical methods of quantitative analysis and routine determinations of the minor metallic components of soils and plant samples can now be carried out with a precision generally better than ± 10 per cent. for a single determination. Attention is being given to increasing the speed of analysis without decreasing the accuracy. Spectrochemical methods of analysis are usually associated with the determinations of very low concentrations. However, the technique may be used for suitable elements at any concentration and work on the estimation of some of the major components of soils has shown that it will be practicable to use spectrochemical methods for determinations of this type. Investigation of such matters as background correction and interaction of elements in the arc column have been continued. It has been found that an entirely satisfactory correction can now be made for the intense background in soil spectrograms. The method of quantitative analysis which involves an addition to the sample of a known amount of the element to be determined gives good results when applied to soils.

The air-acetylene flame method of spectrochemical analysis has now been used for the determination of exchangeable cations in several hundred samples of soil free from calcium carbonate. Very satisfactory values are readily obtainable for calcium, potassium, and sodium. The error associated with the determination of magnesium is somewhat greater. The spectrochemical determination of exchangeable cations in calcareous soils continued to present difficulties.

Examination of type samples collected during the progress of soil surveys has continued steadily throughout the year. Samples have been submitted to special determinations, in addition to the usual routine descriptive analyses, to assist in elucidating the pedological problems. Such analyses have included detailed examination of the clay fraction, analyses of hardpans, ironstone gravels, and manganiferous concretions found in soils, and the examination of various parent materials from which soils have been formed. A large series of gypsum samples from deposits in the Wakool Irrigation Area was also examined.

4. SOIL PHYSICS.

(*a*) *House Foundations.*—Soil surveys of a number of building estates have been carried out to provide information regarding foundations for the Victorian Housing Commission. As a result of this work and of field examinations elsewhere in the suburbs, it has been possible to prepare a reconnaissance map of the soils of Melbourne. The purpose of the map is to distinguish the areas in which soils that are basically different in physical and engineering characteristics may occur. It was found that the dominant factor affecting the physical properties of the soils near Melbourne is the underlying geological formation. The association of soil type with parent material and topography assisted the mapping materially. Seven soil associations are mapped and within them fifteen soil types are defined.

This map will be used as the basis for the field programme of determining the physical characteristics of the soils of Melbourne, particularly with a view to understanding their relation to building foundations.

A start has been made on the preparation of a similar map for the suburban areas of Adelaide, where the soil pattern is more complicated and no geological plan is available. The Mines Department of South Australia is at present preparing such a plan and geological and soils officers will be co-operating closely on the Adelaide work.

(*b*) *Seasonal Changes in Water Content under Houses.*—Changes in water content and the accompanying movement of soil are of great importance in relation to the stability of clay soils. Water content changes are being followed in test huts provided by the Victorian Housing Commission and the Housing Trust of South Australia in the suburbs of Melbourne and Adelaide respectively. These measurements are now being supplemented by results coming forward from a number of installations for measuring soil movement. Striking trends are already shown by both sets of data, but a longer period is required before sufficient information is available from all sites for definite conclusions to be reached.

Data relating to water content have been obtained also from a site at Villawood, New South Wales. These have been provided by the Commonwealth Experimental Building Station from an installation made by the Division in connexion with their experimental foundations on that site.

(*c*) *Measurement of Water Content of Soils.*—For many purposes it is desirable to be able to follow changes in the water content of soils without disturbing the soil every time samples are needed, particularly in the investigations being carried out in relation to house foundations. It has been found convenient to do this indirectly by measuring the electrical conductivity of gypsum blocks embedded in the soil. The blocks in present use have certain disadvantages and efforts have been made recently to improve them by using various types of plaster and by using concentric electrodes. This work was done by an officer of the Division located temporarily with the Building Research Section. The use of concentric electrodes effected some improvement but did not eliminate errors due to the penetration of saline soil solution into the blocks. A thermal method is also being tried out as an alternative to the electrical conductivity method.

A pressure device for controlling the water content of soil samples is being used in connexion with the calibration of gypsum blocks for interpretation of electrical conductivity in terms of water tension and water content. A new resistance bridge for measurement of gypsum block resistances in the field has also been constructed. This bridge represents a considerable improvement over equipment used until recently.

(*d*) *Entry of Water into Red Loam Soils.*—In connexion with soil survey work proceeding in the neighbourhood of Lismore, New South Wales, an investigation into the infiltration characteristics of soils in that district has shown that the rate of water entry into the red loam soils when initially dry is high for soils of such high clay content. Many farmers in the district consider that the quantity of water entering these soils has decreased in recent years and they have attributed this to "sod bound" conditions in the paspalum pasture. The infiltration trials did not show that the pasture cover had this effect. However, it was observed when this work was carried out that the soils under paspalum had a high water content which was probably due to the low transpiration rate of paspalum during its dormant period from May to September. This would be sufficient to account for low infiltration rates during that part of the year.

(*e*) *Infiltration Measurements.*—Work has been continued on spray and flood methods for measuring the water entry characteristics of soils. An inverse relation has been found to exist between minimum infiltration capacity and the fraction of the total water applied to a plot that remains within the soil immediately under the plot. This relation is consistent with the use of a factor recently introduced to correct for the effect of size of plot on infiltration data derived from small test plots.

(*f*) *Evaporation of Water.*—Co-operative work has been continued with the University of Adelaide at the Waite Institute on the use of the Piche evaporimeter. The effect of wind has been studied and a relation worked out between weekly evaporation at the Waite Institute from a standard tank evaporimeter and from a Piche evaporimeter after correction for the effect of wind.

(*g*) *Soil Structure.*—Methods for examining soil structure have been investigated in connexion with work being done on the maintenance of good physical conditions for crop growth. The object has been to introduce refinements which will help reveal minor differences in the stability of structural aggregates in water. In the course of this work, the effects of time of shaking in water, flood and capillary wetting, and apparatus characteristics on the measurements have been examined and a modified procedure adopted. Work on a new procedure for measuring the mechanical stability of dry structural aggregates has been continued.

The structure of soils from Lismore, New South Wales, has been examined and the high stability of the red loam soils there has been confirmed.

(*h*) *Soil Colloids.*—X-ray and associated work on the brown solonized (mallee) soils has been concluded and it has been found that the clay mineral illite is widely represented in these soils. An examination of red loam soils is now being undertaken, a start having been made with soils from the Lismore district in New South Wales. A preliminary examination has also been made of colloids in certain soils in the Northern Territory in connexion with the soil and potentiality survey being conducted there by the North Australian survey party.

Different soil colloids expand and contract to a different degree corresponding to changes in water content. This is of importance in regard to work being done on the properties of soils which are liable to cause cracking of houses in the Adelaide suburbs. An examination is therefore being made of the soil colloids associated with this problem.

5. Soil Microbiology.

Work on *Rhizobium,* the genus of bacteria responsible for nodulation of leguminous plants, continues to be the main theme of activities within the Soil Microbiology Section.

Greenhouse experiments on the effects of using single and mixed strains of bacteria within the three species *Rhizobium meliloti, Rhizobium trifolii,* and *Rhizobium leguminosarum* have shown that the magnitude of the response differs considerably according to which host plant has been used. In some host plants there was no significant difference in dry weight and nitrogen content data between the response to a single highly effective strain of the bacteria and the response to a mixture of effective strains, but in other plants, particularly in certain of the medic-melilot and clover groups, a definite trend of increased yield seemed to follow use of a mixed inoculum. However, before the evidence can be regarded as conclusive it will be necessary to compare carefully the growth of these host plants with each separate strain employed in the mixture, and to try to evaluate just wherein any observed differences may lie. This has been incorporated in part of the greenhouse programme which is just being commenced.

One major difficulty in maintaining a large culture collection of strains of *Rhizobium* from widely different places and times of isolation is to assess the purity of the culture in terms of its regular effectiveness in nitrogen fixation in association with a suitable leguminous host. In the nodule, *Rhizobium* is frequently found in association with the morphologically similar, though non-nitrogen-fixing, *Agrobacterium radiobacter*, and an isolation may not always be strictly pure because of their close similarity of cultural characters. In the course of time the slightly more vigorous *Agrobacterium* may overcrowd the *Rhizobium* with little outward change in appearance, and the culture becomes no longer true to label.

A method has been tried of growing the *Rhizobium* culture collection in a range of alkaline media, and those which show growth at pH 9.0 or more have been regarded as temporarily suspect of contamination. The greenhouse programme this year includes investigation into whether such ability to grow under alkaline conditions can be correlated with any loss in powers of nodulation, and hence whether the organism may still be legitimately regarded as a bona fide *Rhizobium* or not.

The greenhouse test still continues to be the most reliable method of assessment of the value of a commercial culture, but it has the inherent difficulty that its use is restricted to those months in which the bulk of commercial cultures for the season are being prepared or have already been sent out. The use of constant-temperature cabinet equipment available at the Waite Institute for trials over the summer months has not proved an effective substitute, primarily because of lighting difficulties, and these are reflected in poor total plant growths with little nitrogen fixation. Under these circumstances it is not possible adequately to test strains of *Rhizobium* for their nitrogen-fixing ability where such factors are limiting, and until considerable outlay in capital equipment can be made the greenhouse test will remain the routine check on commercial strains.

This year has also seen a further increase in the demand for cultures of *Rhizobium* for seed inoculation by growers on a commercial scale. Over the last three years the increase in post-war acreages sown has been reflected in the steadily increasing demand for commercial cultures. In South Australia such commercial cultures are prepared in the bacteriological laboratories of the C.S.I.R.O. Division of Soils, and the demand is heaviest over the period of autumn sowings from March to May inclusive. In the 1949 season 1884 cultures were requested. The production of such cultures has grown from an experimental laboratory project to the scale of a commercial enterprise and has imposed a severe strain upon laboratory space, equipment and labour. Moreover, the position is most acute at a time when considerable attention is needed to initiate greenhouse pot trials and experiments.

A method has been developed for the estimation of numbers of viable bacteria in a nodule. It consists of crushing the excised nodule in an aliquot of sterile water to prepare a uniform suspension which is serially diluted and used to inoculate a set of liquid media from which on incubation and growth the most probable number of organisms in the original suspension may be statistically estimated. This method has been applied to the rather unusual nodules developing on subterranean clover plants grown on a ground-water podsol at Wattle Range in south-eastern South Australia. Plants developing from seed inoculated with a tested effective strain of *Rhizobium trifolii* produce nodules which soon develop characters indicative of an ineffective association. These nodules are rather flabellate, softer in consistency, several times larger, and frequently convoluted by comparison with healthy nodules of the same age from plants grown from the same batch of seed in sandy loam soil. Compared to the healthy nodules, these large nodules in Wattle Range soil support a bacterial population of the order of forty times greater. What factor or factors cause this unusual proliferation with simultaneous alteration from effective to semi-parasitic plant-bacterial relationship is still a matter of conjecture.

A photoelectric photometer capable of colorimetric and nephelometric determinations is at present being built in the Divisional workshop, and when in operation will greatly extend the scope of investigations into the longevity and growth of *Rhizobium* in soils and artificial culture and the metabolism of iron-reducing bacteria similar to *Bacillus polymyxa* which play a part in glei formation in sub-soils.

III. PLANTS.

1. General.

The importance of primary industries in the Australian economy has naturally placed considerable emphasis on investigations of plant problems. The Organization's work in this field is undertaken mainly by its Division of Plant Industry, which has headquarters at Canberra and experimental farms and stations at a number of centres throughout the Commonwealth.

Work on the special local problems of irrigation districts is undertaken at the independent Commonwealth Research Station (Murray Irrigation Areas) at Merbein, Victoria, and Irrigation Research Station (Murrumbidgee Irrigation Areas) at Griffith, New South Wales (*see* Chapter IV.).

The Division of Entomology is carrying out work on weed control, insect pests of pastures and crops, and insect vectors of virus diseases (*see* Chapter IX.).

Work undertaken within the Division of Biochemistry and General Nutrition on mineral nutrition of plants in the Ninety-Mile Plain, South Australia, is reported in Section 22 of this Chapter. Investigations have been made in the Division of Soils into guayule as a source of rubber (*see* Section 23) and in the Section of Mathematical Statistics on the trend in yield throughout the wheat belt in South Australia (*see* Section 24).

Division of Plant Industry.—The remainder of this Chapter outlines the work in progress within this Division.

Difficulties of accommodation resulting from shortage of buildings in Canberra still obtain, but the laboratory at Deniliquin may be ready for occupation within a few months.

The North Australia Regional Survey continued its operations, completing the second year of the Barkly Tableland reconnaissance. The report on the Katherine-Darwin area has been revised for printing.

Much of the material collected by the Senior Plant Introduction Officer in South America has reached Australia and is being grown under quarantine conditions in Queensland and in North Australia.

For two years co-operative tobacco trials near Ayr with the Queensland Department of Agriculture and Stock have given promise of satisfactory development in this area. The leaf from the experiments during the two seasons was of high quality and gave a highly economic yield.

During the year the Division of Plant Industry was responsible for the conduct of two conferences of State and Commonwealth Officers. The first, on seed testing, was held in Launceston in November, 1948, and brought to conclusion nearly fifteen years' work aimed at achieving uniformity in methods and standards for seed testing in Australia. The second conference was held in Melbourne in May, 1949, and was concerned with plant diseases, particularly those responsible for food losses.

2. PASTURE INVESTIGATIONS.

Work on pastures has been based on Canberra, Trangie, Deniliquin, Armidale, Perth, Kojonup, Cunnamulla, Lawes, and Ayr. Investigations in progress at these centres are described in greater detail in Sections 3–10 below, and pasture experiments at the Kimberley Research Station are reported in Section 14.

The principal phases of the programme have been concerned with:

(*a*) Ecology and management of native pastures,
(*b*) Pasture establishment, including studies of species and strains,
(*c*) Plant nutrition studies,
(*d*) Irrigated pasture problems,
(*e*) Pasture studies in relation to animal diseases.

Until recent years sheep pastures have received more attention than others, but increased interest is now being taken in the development of cattle pastures in the northern summer rainfall regions.

The work on pastures is closely allied with the work on weeds and on plant introduction reported in Sections 11 and 12 below.

The Division of Entomology is undertaking work on pasture pests, particularly pasture cockchafers, which is reported in detail in Chapter IX., Sections 8–10.

3. PASTURE INVESTIGATIONS AT CANBERRA.

(*a*) *Studies on Sown Pastures.*—The study of the problem of the decline of Wimmera ryegrass in ryegrass-subterranean clover pastures has continued. It has been established that the population of plants is adequate in stands showing sharply declining yields, and that the low vigour of the plants is the immediate factor in the decline. Treatments designed to alter the physical status of the soil, such as cultivation, subsurface tillage, and compaction have given negligible results. Removal of the associated clover, or treatments giving a reduction in the density or vigour of the clover, have given some increase in the yield of grass, possibly by reducing the shading of weak ryegrass plants.

An experiment on the interaction of phosphorus and nitrogen has clearly demonstrated that the status of these nutrients is all-important in governing the grass development. The application of phosphorus or nitrogen alone to a clover-dominant, untopdressed pasture gives little increase in grass yield but the combination of these nutrients gives a balanced sward with high grass yields. Both phosphorus and molybdenum have an influence through their effect on nitrogen fixation by the clover and thus on nitrogen status of the soil. It is considered that the immediate causes of decline are now clear and experiments are proceeding to examine further the significance of these findings, particularly those on nitrogen status, under grazing conditions.

The rapidity with which a subterranean clover pasture attains full production depends on the initial stand. Sown with either phalaris or Wimmera ryegrass, clover yields even at the end of the third year are influenced by the first year's establishment. Wimmera ryegrass also varies in yield at the end of the third year in accordance with the original sowing rate.

On the other hand, phalaris becomes more or less uniform in plant numbers and yield within a few years, provided that the initial rates are adequate to produce a complete sward. On well-prepared soils, 2 lb. is an adequate rate to give such a full sward.

An experiment was commenced in 1948 to determine the influence of spacing on forage and seed production by *Phalaris tuberosa.*

Work at the Dickson Experiment Station on the establishment of various pasture species when sown with cereal crops has demonstrated that with annual pasture species an ample quantity of seed will be set to permit satisfactory pasture development in the following year. The development of the pasture in the season following the harvest of the crop is frequently limited by fertility rather than by numbers of plants. On the other hand, with perennials such as lucerne or phalaris, the first-year establishment of plants largely determines the subsequent success of the sward. Cover crops may seriously depress establishment and prevent the subsequent development of a full sward, but results vary according to seasonal conditions and may be influenced in some degree by the spacing of the cover crop.

A series of experiments is in progress to determine the inter-relationships of competing plants. The influence of density and fertility level on the development of pure cultures of annual pasture species has been studied and work is commencing on perennials and annuals in mixed cultures.

A study has been in progress since 1945 on the influence of season and variety on the length of the period of dormancy of subterranean clover seed. Results to date indicate that each of these factors is of significance.

(*b*) *Plant Nutrition Investigations.*—Field trials and complementary pot-culture trials were continued to determine the nutrient requirements of pastures on a range of soils on the Southern Tablelands of New South Wales. Though the soils vary greatly, and some are extremely poor, high yields of sown pasture have been obtained by appropriate fertilizer treatment. Deficiencies of nitrogen, phosphorus, sulphur, and molybdenum are widespread. Responses to sulphur have been obtained on soils of sedimentary, granitic, and basaltic origin, and responses to molybdenum on all except the basaltic soils.

Both molybdenum and sulphur were found to be of particular importance for symbiotic nitrogen fixation. It was found that molybdenum has a dual role. Very minute quantities are required to permit nitrate utilization in plants, and appreciably greater quantities are needed specifically for symbiotic nitrogen fixation. On these soils, the minute amount of molybdenum available from the soil was ample for nitrogen metabolism within the plant, but insufficient for symbiotic nitrogen fixation. Sulphur appears to increase modulation and symbiotic nitrogen fixation primarily through its effect on nitrogen metabolism within the plant. In its absence there is an accumulation of soluble nitrogen compounds and this directly or indirectly inhibits the process of symbiotic nitrogen fixation.

On certain more acid soils failure of clover is due both to low reaction and to deficiency of calcium. Treatment of these soils with lime induces normal modulation, and excellent growth can be obtained by the use of lime and superphosphate. Sedimentary soils are most affected, but modulation failure occurs on some granitic soils and has been observed on one small area of soil of basaltic origin. Most of these soils are deficient also in molybdenum, and the effect of lime is almost certainly concerned with its effect on the availability of soil molybdenum. This work is being continued.

Pot-culture studies on the red basaltic soils of the north coast of New South Wales are being continued. This work is conducted in co-operation with the New South Wales Department of Agriculture. Trials in progress show a very marked effect of phosphate and some further effect of molybdenum on the growth of white clover. The previous year, white clover on a soil from the same site was very unthrifty and much poorer than on a local podsolized soil. The reason for the difference in behaviour of the plants in the two years is difficult to understand, and further work is needed to clarify the problem.

Work has also been commenced on an investigation of the mechanism of terminal oxidation in subterranean clover. The presence of polyphenol oxidase in this species has been established.

(*c*) *Pasture Surveys.*—Field work on the vegetation survey of the south-west slopes and adjacent plains of New South Wales is almost complete. Study of the associated pasture types is proceeding. The area carries various of the western communities described by Beadle and of the tableland communities described by Pryor, together with the *Eucalyptus albens* association, not previously described.

The study of the phenology of the natural pastures of the Canberra region and of the degeneration of the grassland under the influence of grazing is continuing.

(*d*) *Toxaemic Jaundice Studies.*—Co-operative work with the Division of Animal Health and Production and the New South Wales Department of Agriculture (*see* Chapter VII., Section 15(*b*)) is in progress in connexion with the incidence of the sheep disease complex, toxaemic jaundice. The studies on the botanical composition of pastures of affected properties were concluded in February, 1949. Attempts were also made during the season to obtain a more accurate assessment of the botanical composition of the diet of the sheep as contrasted with the composition of the feed available. Preliminary data have been collected on the ecology of *Heliotropium europaeum,* a weed shown to be directly responsible through liver damage for a large numer of mortalities previously attributed to toxaemic jaundice. Evidence so far available also suggests that sheep grazing on *Heliotropium europaeum* are more likely to develop an abnormally high liver copper content.

A pot-culture experiment was completed on the copper and molybdenum content of three pasture species on a wide range of soils. It was shown that *Erodium Cygnorum, Medicago denticulata,* and *Hordeum leporinum* have a decreasing copper content in that order, and that there is no consistent difference in the copper or molybdenum content of these species when grown on "affected" and "unaffected" soils.

A further pot-culture experiment has been done to determine the relationship of growth stage in oats to copper and molybdenum uptake. Chemical analyses are not yet complete.

(*e*) *Pasture Chemistry.*—It is suspected that the distribution of certain pasture species in Australia, notably the legumes, may be influenced by phosphate availability. Work is proceeding to determine the relative availability of soil phosphorus fractions to different plant species.

A comparison is being made of the mineral uptake by a wide range of varieties of subterranean clover. It is also planned to make a survey during 1949 of the mineral status of subterranean clover throughout the zone of its occurrence in New South Wales.

4. Pasture Investigations at Trangie, New South Wales.

The grazing trial conducted in co-operation with the New South Wales Department of Agriculture is continuing. The main objectives are the determination of the influence of rate of stocking and of spring and autumn deferment on the botanical composition and condition of a *Stipa-Chloris* pasture and on the relationship of such pasture changes to live weight and wool production in Merino wethers. Pasture cuts have been made at bimonthly intervals, the yield of green herbage (with the yield of annuals in brackets) from March, 1948, to January, 1949, being 2.69 (0.57), 5.04 (1.41), 9.01 (6.03), 21.20 (15.21), 5.62 (0.54), and 2.64 (0.14) cwt./acre. The rate of stocking, but not the deferment treatments, is reflected in the yields. Seasonal conditions have been favorable since the initiation of the trial in March, 1948, and even the most heavily stocked pastures have not as yet been subject to severe grazing pressure.

A survey is proceeding to determine the botanical composition of natural pastures in the Trangie district on various soil types and under different grazing intensities. The survey is being conducted both by the study of differences between contiguous paddocks, differently grazed, and by transects within paddocks, running from points of greatest to least intensity of grazing and treading. Two series of degeneration stages have been determined, one on the heavy and the other on the light soils of the area. On the heavy soils the *Stipa falcata* dominance yields to *Chloris acicularis,* then to *S. setacea* or *Eragrostis lacunaria,* and finally to *Chloris truncata. Medicago laciniata* and *Erodium cygnorum* are characteristic annuals in heavily grazed pastures. On heavy soils the sequence of perennial dominance is *Stipa aristiglumis-Sporobolus caroli-Stipa setacea-Danthonia* spp.-*Chloris truncata.*

Scald vegetation studies are also in progress. The work includes the mapping of scald edges and species zones, basal area measurements and charting of perennial grasses within permanent belt transects across the scalds, estimation of density of annuals, and charting of typical areas of pasture showing apparent weakening. Contour plans of each scald under study are also being made. These data are providing information on scald structure in respect to both soil and vegetation, and it is hoped that such studies will contribute to the understanding of scald formation and regeneration.

Observations are being made on the field germination of *Medicago* spp. Germination is restricted by temperatures during the summer, even when moisture conditions are favorable.

5. Pasture Investigations at Deniliquin Regional Pastoral Laboratory.

The building of the main laboratory was commenced in October, 1948, and it is hoped that it will be occupied later in 1949. The area developed for irrigation at the Falkiner Memorial Field Station now totals 100 acres.

(*a*) *Plant Investigations.*—Studies on the establishment and productivity of winter and summer growing fodder and pasture species on heavy "plains" soil and coarser textured soil have been continued. Experiments sown in autumn 1947 showed little influence of cover crops or of their sowing rate or spacing on the 1948 development of pastures of annuals or of perennials. The experiments sown in spring 1947 with and without cover crops, gave poor pastures throughout and demonstrated the difficulty of establishing small seeded European pastures species under irrigation in spring.

Since plant establishment on the soils of the region is a major problem, studies were commenced in 1949 to determine the factors involved in the emergence of seedlings of pasture and forage crops sown over a range of autumn and spring conditions and with various organic litter treatments, fungicide treatments, and depths of sowing. Detailed records will be maintained of surface soil temperature, moisture content, and penetrability.

Experiments begun in 1947 to determine the value of pre-treatment cropping with cereals prior to the sowing of pasture mixtures have shown little or no effect of such pre-treatment either on soil structure or on pasture establishment. On the other hand, studies on the influence of soil surface ameliorants (lime, gypsum, sand, superphosphate, and bitumen emulsion) on emergence indicate definite treatment effects where the ameliorants are placed in the drill row.

A number of species trials is now in progress. These involve the testing both of strains of recognized pasture plants and of many newly introduced species. It seems that the range of useful species will extend beyond the cool temperature and Mediterranean species now in use in the region.

Studies are in progress on major and minor element nutrition on these heavy soils. No definite responses to minor elements have yet been recorded.

The study of the environment and the vegetation of the Falkiner Memorial Field Station has been completed and prepared for publication.

An ecological study has commenced to determine the influence of intensity of grazing on *Danthonia semiannularis* grassland. The area has been fenced and pre-experimental sampling has been completed. Grazing commenced in May, 1949.

(*b*) *Soils and Irrigation Studies.*—Studies on the soil moisture régime of two contrasting soil types were continued. The relations established between application, infiltration, and soil moisture indicate that it should be possible to define the irrigation requirements of a soil from a knowledge of its infiltration characteristics and the soil moisture status when the infiltration tests are made. When these values have been related to the application of water to a particular soil, definition of the irrigation technique to give the required amount of water most efficiently can be attempted.

Work on the relation between slope, flow, and time of application on border-check irrigation has been widened to include a heavy plains soil as well as the lighter type. Water gradient and run-through have been measured. The expression for time of advance, $T = KD^a$, where D is the distance and K and a are constants, has been confirmed. Factors influencing time of advance and absorption have been studied. On these soils penetration beyond the first foot of soil is small or negligible within the flow ranges studied.

Comparison of border-check and contour irrigation has continued.

6. Pasture Investigations at Armidale, New South Wales.

(*a*) *Grazing Management Studies.*—On a representative natural pasture, experiments involving a comparison of (*a*) different rates of stocking and (*b*) continuous versus rotational grazing are being carried out in co-operation with the Division of Animal Health and Production (*see* Chapter VII., Section 16). In these experiments a study is being made of the effects of different grazing treatments on—

(*a*) Infection by internal parasites,
(*b*) Wool production,
(*c*) Live weight and growth of sheep,
(*d*) Yield and botanical composition of the pasture,
(*e*) Chemical composition of the pasture.

The trials have not been in progress sufficiently long for the effects of grazing treatments to become manifest, but data obtained so far indicate the relatively low yields of the pasture (less than one ton of air-dry forage per acre throughout the 1948-49 summer) and its gramineous nature; the approximate botanical composition by weight of the green material is grass 90 per cent., legumes 1 per cent., and miscellaneous species 9 per cent.

(*b*) *Species Trials.*—The testing of a range of forage grasses and legumes is being continued and expanded. Among the legumes, various strains of lucerne continue to give the best overall, as well as the best winter production. Subterranean clover did not yield as well during the colder 1948 winter as during previous winters. *Festuca mairei* was the outstanding grass during 1948, with *Phalaris tuberosa,* cocksfoot (C.P.I. 2145), tall fescue, awnless brome, and perennial ryegrass also producing well. A range of strains of crested wheat grass showed promise in their first year. Sheep's burnet (*Poterium sanguisorba*) continues to yield well and has proved palatable to sheep on all soil types on which it is being tested.

In a trial designed to test the persistence of subterranean clover varieties, Dwalganup gave the lowest yield (as was to be expected) in the first year. There was no difference in the yield of Tallarook, Mount Barker, and Bacchus Marsh varieties.

(*c*) *Fertilizer Trials.*—In two experiments on a sown pasture (*Phalaris tuberosa,* red clover, and subterranean clover) on a granitic sandy soil the need for the various major elements and the minor elements, copper, boron, molybdenum, zinc, cobalt, and manganese was investigated. None of the minor elements produced a marked response from the pasture.

In a rate of application of superphosphate trial on a pasture of *Phalaris tuberosa,* red clover, and subterranean clover, the total yield of the pasture in November, following applications of 100 lb. per acre of superphosphate in the autumn, followed by 100 lb. per acre in the spring, was 30 per cent. higher than the control. The yield from this fertilizer treatment was also significantly higher than that from 200 lb. applied in autumn.

(*d*) *Pasture Establishment Studies.*—In 1948 a trial of the following methods of establishment of a pasture of *Phalaris tuberosa,* red clover, and white clover was made:—

(*a*) Broadcast,
(*b*) Drilling with seven-inch row spacing,
(*c*) Cross drilling with seven-inch row spacing,
(*d*) Alternate rows (seven-inch spacing) of phalaris and clover.

At the end of the establishment year the highest yield was recorded from the 7-inch drilling treatment.

(*e*) *Improvement of Natural Pastures.*—In a dense red grass (*Bothriochloa ambigua*) pasture, the effect of mowing and removing the remains of the previous summer's growth of grass on the establishment and early yield of late (May) sown white clover was to reduce the establishment by 27 per cent. and the yield (in the following summer) by 48 per cent.

7. Pasture Investigations in Western Australia.

(*a*) *Grazing Management Trial.*—Following completion of the *Ehrharta* grazing trial at the Institute of Agriculture, Perth, in April, 1948, the experimental area was sown to oats, Wimmera ryegrass, and sand brome-grass (*Bromus arenarius*) during the winter months. Yield data from the oats suggested that there were no residual treatment effects from the previous grazing trial. The area will be used for a trial of sown annual pasture in which continuous and deferred grazing treatments will be compared, using Merino wether sheep.

(*b*) *Wimmera Ryegrass Investigations.*—Experiments on the extra-grazing factors responsible for retrogression of Wimmera ryegrass in sown pastures have been continued; the 1948 results confirm previous findings. A response to surface cultivation particularly during the winter months was obtained at the Institute in 1948, apparently due primarily to higher establishment rates. Residual effects of deep cultivation in 1946 were obtained at the Institute in both 1947 and 1948. Towards the close of the 1948 season the influence of applied nitrogen greatly exceeded that of any of the cultivation treatments. In a separate experiment the influence of relative dates of establishment of Wimmera ryegrass and subterranean clover on the botanical composition of the pasture has been studied. Marked reduction in the proportion of grass results from a delayed germination of Wimmera ryegrass following earlier germination of the clover.

Single-plant studies from a large number of seed samples of Wimmera ryegrass collected within Australia are being carried out at the Glen Lossie Field Station. No seed lines have yet been found superior to local material. Work on growth rate of the grass under grazing is proceeding.

(*c*) *Nutrition Studies.*—The field experiments commenced in 1947 have been concluded. In both 1947 and 1948 responses to potassium and zinc were obtained with Dwalganup subterranean clover at a number of centres, the effect of potassium being particularly marked on the deep sandy coastal soils. In 1948 the effect of copper also was marked. The possible use of lupins to avoid the potassium deficiency problem is being investigated.

Using pot-culture technique, an interaction effect of potassium and copper was obtained on the growth of subterranean clover on a soil from West Gingin; the response to copper occurred only in the presence of potassium. Work on Muchea sand—a siliceous sand of very low inherent fertility—is continuing; the phosphorus and nitrogen nutrition of plants on this soil presents unusual features.

(*d*) *Pasture Investigations Relating to the Sheep Infertility Problem.*—The three grazing experiments at Narrogin, Wandering, and Kojonup have been continued. Owing to the dry autumn conditions in the south-west of Western Australia in 1948, the pastures contained less clover than usual. No serious infertility problem has yet arisen in the experimental flocks. This phase of the problem will be reconsidered after the results from 1949 lambing are available.

The bio-assay investigations of plant material have revealed that all strains of *Trifolium subterraneum* tested to date are potent, while other legumes, grasses, &c., contain much smaller quantities of the toxic material. No effects of soil or climatic conditions have yet been recorded. Investigations on the effect of stage of growth of clover have shown that there is a marked and rapid decrease in potency during wilting. The dry material appears to be non-potent.

(*e*) *Grazing and Rotation Trial.*—Like work in the previous section, this experiment is being conducted on a co-operative basis with research officers of the State Department of Agriculture and of the University of Western Australia. Results for the three grazing seasons, 1946-47, 1947-48, and 1948-49, have been very consistent. The volunteer pasture (capeweed dominant) is obviously inferior to the others on all points. Grazing treatments which include oats are slightly superior to subterranean clover pasture in that wool production is maintained at a higher level during the summer months. The entire experimental area is to be sown to wheat in the late autumn of 1949 to determine the influence of the pasture phase on fertility status as expressed in wheat yield and quality.

(*f*) *Glen Lossie Field Station, Kojonup.*—This 6,000-acre field station was purchased by the Organization late in 1948. Preliminary work, conducted on the property in the 1948 season by arrangement with the previous owners, included a mineral nutrition trial with subterranean clover, single plant investigations with Wimmera ryegrass, and plant introduction studies. The programme is to be expanded to include studies on the significance of subterranean clover in fertility build-up; species and strains investigations; sheep infertility investigations; plant nutrition studies; and the management of sown annual pastures with particular reference to grass maintenance. Meanwhile the station is being stocked and general developmental work is proceeding.

8. PASTURE INVESTIGATIONS AT CUNNAMULLA, QUEENSLAND.

(*a*) *Grazing Management Studies.*—The grazing management experiment on Mitchell grass pasture with light, medium, and heavy rates of stocking under both continuous and rotational grazing was continued. Changes in the yield and botanical composition of the pasture and in the live weight and wool production of the sheep are being measured. During 1948 there was a steady reduction in yield of total forage under all treatments and in October the yield was approximately 10 and 4 cwt. per acre under the light and heavy rates of stocking respectively. No marked changes in botanical composition occurred, but the previously recorded reduction in the proportion of Mitchell grass under heavy stocking in the rotational system involving summer grazing and winter spelling continued. Towards the end of the year a slight reduction in sheep live weight was recorded under heavy stocking, particularly with rotational grazing, but with medium and light stocking no differences occurred between rates or between continuous and rotational grazing at similar rates. There was no difference in the weight of wool produced on the various grazing treatments, but the value per head was lower with rotational than with continuous grazing at the medium and heavy rates.

(*b*) *Pasture Regeneration Studies.*—On a Mitchell grass pasture where the stand of perennial species had been reduced by previous drought, a trial is in progress which has as its objective the regeneration of the perennials by conservative stocking. Four stocking treatments are involved. The period of two years since it commenced has not been long enough for any effects on regeneration due to stocking treatment to become manifest. As had been noted previously, seasonal conditions and not stocking practice are the dominant influence in pasture regeneration in this region. A fairly high density of Mitchell grass seedlings in 1947 failed to develop even in the absence of stocking.

(*c*) *Yield and Floristics Studies on Miscellaneous Pasture Types.*—Type sites have been established at a number of centres within the Cunnamulla-St. George-Dirranbandi area. Periodic samplings are made after rain to obtain information on the seasonal and botanical composition of the pastures. Chief points of interest recorded to date are the relatively high proportion of legumes in the pastures on the heavy soils of the Moonie River flood country and in general, the higher proportion of miscellaneous (herbage) species on all pasture types sampled, compared with the Mitchell grass pasture on Gilruth Plains.

9. PASTURE INVESTIGATIONS AT LAWES, QUEENSLAND.

(*a*) *Natural Pastures.*—Studies on the natural spear grass (*Heteropogon contortus*) pastures have been continued at "Calliope" and "Rodds Bay" in the Gladstone district and at Lawes, and new work has been commenced near Goomeri and Broweena.

Yield and botanical and chemical composition of natural pastures at "Calliope" have been recorded at 12-weekly intervals during the past two years. Most growth takes places between October and April and is dependent on effective summer rains. Irrespective of rainfall, there is little growth between April and July. There has at all times been a striking preponderance of spear grass, usually exceeding 80 per cent. of the total yield of edible material, while legumes have rarely comprised more than 1 per cent. of the pasture. The protein content of spear grass varied from 1.35 per cent. (for young growth) in January 1947 to 0.5 per cent. in July.

Experiments at "Rodds Bay" have shown that Townsville lucerne (*Stylosanthes sundaica*) can be easily established from surface seeding, and fertilizer trials have shown a marked response to superphosphate extending over a period of four years. This legume is most promising, but final assessment must await the result of grazing trials now in process of establishment.

"Stylo" (*Stylosanthes gracilis*) also has made very good growth with yields exceeding those from *Stylosanthes sundaica*, but its frost susceptibility would impose some limitation on its value in south-eastern Queensland.

Preliminary studies on the effect of burning natural pastures have given clear evidence that fire promotes the germination of *Heteropogon contortus* and that mature plants of this grass are relatively unaffected.

(*b*) *Sown Pastures.*—(i) *Rhodes Grass.*—An experiment designed to assess the relative value of two varieties of Rhodes grass and to evaluate lucerne as a component of Rhodes grass pastures has yielded valuable information. Grazing has been at an intensity of a beast to 1¼ acres. There were negligible differences in stock maintained separately on the two grasses, but the addition of lucerne to either grass had a tremendous effect on live-weight increments.

In the absence of good winter rains, this benefit from a mixed pasture was restricted to the summer months and all stock lost equally in winter. With good winter rainfall, there was some additional advantage from the mixed pasture in August and September.

A satisfactory mixture of grass and lucerne has been maintained, but lucerne yields have rarely exceeded 2.5 cwt./acre per eight weeks and in winter they were less than 0.25 cwt./acre. There was an increase of from 4 to 10 cwt./acre in the yield of grass from mixed pastures during the summer months.

There was no apparent relationship between live-weight increments and the yield of grass, and the better live-weight gains on mixed pasture are attributed to some improvement in the quality of feed (i.e. the presence of lucerne).

Any residual effect of these pastures on soil fertility is now being studied in terms of yield from cereal crops.

(ii) *Paspalum scrobiculatum.*—The value of *Paspalum scrobiculatum* as stock feed during all months of the year has been shown. Carrying capacity can be raised from not more than one sheep per acre on natural pasture to four sheep per acre on pastures of *Paspalum scrobiculatum.*

Experiments now in progress cover four types of pasture: *Paspalum scrobiculatum,* lucerne, *Paspalum scrobiculatum* + lucerne, *Paspalum scrobiculatum* + an annual legume (*Phaseolus lathyroides*). They are designed to give: (*a*) comparison between row and sward method of production, and (*b*) a comparative evaluation of these four pastures, with particular reference to the nitrogen cycle.

(iii) *Alternate Pastures.*—A mixed pasture of Rhodes grass and lucerne provides excellent stock feed in summer, but has limited value in winter; on the other hand, row-pastures of *Paspalum scrobiculatum* and of lucerne will provide good winter feed. An experiment has therefore been designed to gain information on alternate grazing of these two pastures as a means of maintaining growth and production in beef cattle. The necessary plots have now been established and grazing will be commenced during 1949-50 season.

(*c*) *Weed Control.*—(i) *Mintweed.*—Experiments designed to assess the value of chemical sprays for control of mintweed have shown that, at a volume of 20 gallons per acre, sodium-2-methyl 4-chlorophenoxyacetic acid and ethyl 2,4-dichlorophenoxyacetate were equally effective and appreciably better than other preparations. The minimum dosage to give a complete kill of young, actively growing plants, was 1 lb. (active equivalent) per acre; ½ lb. per acre gave 60-70 per cent. kill and suppressed growth of surviving plants for three weeks; 1/5 lb. per acre did not kill and normal regrowth commenced within eight days.

In the absence of competing plants, applications at less than 1 lb. per acre are ineffective; but in spraying a commercial sorghum crop, using ½ lb. sodium 2-methyl, 4-chlorophenoxyacetic acid in a volume of 10 gallons of water per acre, complete control of mintweed was achieved.

(ii) *Forest Timber Regrowth.*—Investigations on the use of hormone weed-killers for killing seedlings and suckers of bluegum (*Eucalyptus tereticornis*) have been continued. Their value is being assessed against that of commercial arsenical weed-killers.

10. Pasture Investigations at Ayr, Queensland.

As part of a project to investigate the possibilities of development in the Burdekin Valley, a grazing trial has been designed to test five grass-legume mixtures as irrigated pasture for fattening beef cattle. This work is being carried out in co-operation with the Queensland Department of Agriculture and Stock. Land for the experiment was selected in 1947, and clearing operations have been completed. A green manure crop has been grown and turned in as a preliminary to planting towards the end of 1949.

11. Weeds Investigations.

(*a*) *Effects of Plant Growth-regulating Substances on Perennial Weeds.*—Complete eradication of deep-rooted perennial weeds with a single application of plant growth-regulating substances has not been achieved. The value of these substances lies in the fact that almost complete control for a single season can be achieved without soil sterilization. It is possible, therefore, to reduce or eliminate the effects of weed competition in crops, to prevent the production of seed by weeds such as skeleton weed and, possibly, to reduce the stand of weeds by repeated annual treatments. The most promising results to date have been achieved with hoary cress (*Cardaria draba*). A reduction of between 70 and 80 per cent. has been achieved on plots eighteen months after treatment with several types of growth-regulating substances but, during the same period, the number of cress rosettes on untreated plots decreased by 50 per cent. due to the cessation of cultivation. The experimental area is being cultivated and it is hoped to obtain definite comparative effects next spring.

With skeleton weed (*Chondrilla juncea*), a high degree of control has been obtained during the spring, summer, autumn, and winter following treatment, but regrowth has occurred in the following spring. The best result achieved has been a 40 per cent. reduction twelve months after treatment with sodium 2,4-dichlorophenoxyacetate. The effects of annual re-sprays are being determined.

The sodium salt of 2,4-dichlorophenoxyacetic acid gave the best results with nutgrass (*Cyperus rotundus*). However, in no instance was a worth-while measure of control achieved. In most instances the tubers from which the leaves grew were killed but the more deeply situated tubers were not affected.

Initial tests on woody perennials such as blackberry (*Rubus fruticosus*), sweet briar (*Rosa rubignosa*), and African boxthorn (*Lycium ferocissimum*) using salts and esters of 2,4-dichlorophenoxyacetic acid gave disappointing results, and no degree of control was achieved.

(*b*) *Effects of Petroleum Oils on Monocotyledonous Weeds.*—The effect of spraying petroleum, shale, and coal-tar oils on *Paspalum dilatatum* has been studied with a view to elucidating the action of oils on plants, particularly perennial grasses. Paspalum was chosen as the test plant because of its importance as a weed in irrigation areas.

The effect of different times, rates, and frequencies of spraying with various oils has been evaluated. Early spraying is ineffective and maximum effect of single sprays is obtained in the December-January period, i.e. during the period of maximum seedhead development.

The quick action described by overseas workers has resulted from spraying with oils containing a high percentage of unsaturated hydrocarbons, mainly aromatics. Quick-acting oils such as commercial power kerosene give a rapid kill of top growth followed by relatively rapid re-growth. Oils having a slow action contain less unsaturated hydrocarbons and although kill of top growth may take a week or more, re-growth is much weaker and slower than that following spraying with quick-acting oils.

A diesel distillate with a boiling range of 376-678° F. and a sulphonatable content (98 per cent. sulphuric acid) of 23 per cent. by volume is the most promising oil used to date. Plots sprayed with this oil at the rate of 500 gal./acre in January had produced little growth by March. In the 1948-49 season, work with diesel distillate has indicated that economic control of paspalum by spraying with oils is a distinct possibility in the Murrumbidgee Irrigation Areas.

There is an indication that annual grass species such as *Echinochloa crus-galli* are more effectively killed by quick-acting oils such as power kerosene than by slow-acting oils like diesel distillate. Preliminary experiments have been conducted also on the use of chlorinated benzenes for the control of submerged weeds, such as *Potamogeton* spp. in irrigation channels. One of the chief problems has been the formation of a stable emulsion.

(*c*) *Preliminary Tests with New Weed-killers.*—Small-scale tests with allyl chlorophenyl carbonate, a compound reported to have selective growth-regulating effects on monocotyledons, have given disappointing resuts on nutgrass and couch grass (*Cynodon dactylon*).

Ammonium trichloroacetate at 100-200 lb./acre has given excellent results on couch grass; no re-growth has occurred six months after treatment. Promising results have been obtained on nutgrass, but a final assessment will not be possible before next summer. This compound appeared to act as a temporary soil sterilant and was most effective when applied to moist soil. One of its features is the relatively short period of soil sterilization following application.

(*d*) *Low-volume Applications of Plant Growth-regulating Substances.*—Tests using standard volumes (100 gal./acre) and low volumes (3-20 gal./acre) have not shown marked differences in herbicidal effect, except on densely growing shrubs where higher pressures and higher volumes appeared more satisfactory.

Successful field trials have been conducted on the Darling Downs using low-volume applications for the selective control of mintweed (*Salvia reflexa*) in grain sorghum crops.

(*e*) *Soil Fumigants for the Control of Nutgrass.*—Experiments conducted at Tenterfield, New South Wales, have demonstrated the effectiveness of chloropicrin and DD for the control of nutgrass on tobacco growing areas.

(*f*) *Mistletoe* (*Loranthus spp.*) *Control.*—Investigations in collaboration with the Forestry and Timber Bureau indicate that by means of an appropriate dosage of copper sulphate it is possible to kill about half of the mistletoes on yellow box without undue injury to the trees, but more work is necessary to determine whether such results have any practical application. The season of application does not markedly influence the effects of copper sulphate treatments, but does influence the effects of some other poisons. In tests with twenty other poisons, only four so far have yielded promising results. As long as a year may be required to observe the full effects of a treatment. Radioisotopes have given useful information on the movement of compounds of iron, zinc, and cobalt injected into trees infected with mistletoes.

(*g*) *Translocation of Poisons.*—With bean plants it has been shown that the effect of applied "Methoxone" depends on the time of day at which application is made. The effect of "Methoxone" is largely independent of the osmotic concentration of the solution used when potassium chloride is used to vary the osmotic pressure.

(*h*) *Studies of* 2, 4-D.—It has been shown that 2, 4–D increases the rate of destruction of indole acetic acid by a crude enzyme extract, and that a heat-stable inhibitor present in the extract reduces the rate of destruction. This counter-action of 2, 4–D appears to disturb the equilibrium between production and destruction of indole acetic acid, suggesting a mechanism for the action of 2, 4–D.

Analyses are in progress to determine the depletion of carbohydrates by 2, 4–D.

(*i*) *Biological Control.*—Work on the biological control of St. John's wort and lantana is in progress within the Division of Entomology. It is reported in detail in Chapter IX., Section 6 (*a*) and (*b*).

12. PLANT INTRODUCTION.

(*a*) *Introduction and Exchange of Plants and Seeds.*—The overseas exchange activities of the Section have expanded greatly during the year, the number of samples received (1,101) being an increase of more than 50 per cent. on the figures for the previous year, while there was almost a four-fold increase in those sent in exchange, which totalled 2,552. The countries of south-eastern Europe continue to figure prominently among the recipients, but large collections have also been sent to Cuba, Portugal, the United States, Brazil, and Canada. On the other hand, countries of the Western Hemisphere, especially the United States, Brazil, and Argentina, supplied most of the introductions received.

Pasture and forage plants accounted for more than half of the samples received, with cereals, vegetables, tobacco varieties, and oilseeds also prominent. Many samples have been supplied to research organizations in Australia for trial, including collections of *Allium* varieties for use in onion disease investigations and of *Potentilla* varieties for trial as hosts for strawberry aphis.

Great care is exercised in handling this material to minimize the risk of introducing diseases, insect pests, and potential weeds, and close contact is maintained with the Commonwealth plant quarantine authorities.

(*b*) *South American Collections.*—While no active plant exploration has taken place during the year, many of the samples collected in South America during the previous twelve months have now been received. Every effort is being made to build up seed supplies of these introductions as rapidly as possible so that they may be fully tested in suitable regions of Australia and in other countries of the British Commonwealth which have expressed interest in them. This nursery multiplication is being undertaken at the Plant Introduction Station at Redland Bay, near Brisbane, and in the glasshouses at Canberra. With the co-operation of officers of the Queensland Department of Agriculture and Stock several varieties of peanuts have been selected for regional trials in Queensland and the Northern Territory.

As the plants have not yet been grown for a full season, no full assessment of their value is possible, but among those which appear attractive are grasses of the genera *Paspalum* and *Chloris,* and the legumes *Arachis, Adesmia, Desmodium,* and *Stylosanthes. Crotalaria paulina* (C.P.I. 11786) is promising as a green manure species, while a bushy variety of velvet bean (C.P.I. 11843) appears useful as a grain legume. However, spot tests have shown that some of the introductions of *Chloris* and *Crotalaria* may be toxic, and further tests will be necessary before they can be released.

A comprehensive report has been prepared on the South American collecting expedition, with a detailed inventory of the collections.

(*c*) *Pasture and Forage Plants.*—Studies with pasture and forage plants comprise (i) nursery row trials at Canberra, Redland Bay, Lawes, Katherine, and Perth, (ii) replicated trials of promising species at these centres, (iii) regional trials at suitable localities in different climatic zones, and (iv) grazing trials. Most of the trials in the last two categories are conducted in co-operation with the Agrostology Section or with State Departments of Agriculture.

(i) *Nursery Trials.*—At Canberra, two grasses derived from wheat—*Agropyron* crosses have continued to show promise in their second year of trial, and have been rather more productive than phalaris during the summer months. Two strains of cocksfoot have been superior to all other varieties of this grass, and will be tested in comparison with a range of the best Danish types during the coming season. Of the other grasses, two species from Portugal are the most promising. These are *Anthoxanthum amarum,* a vigorous, densely tillered species, and a fine-leaved, densely-tillered strain of tall fescue. Two unnamed species of *Trifolium* from Tanganyika made impressive growth during the summer months.

Of the recently-introduced legumes under trial in Western Australia, varieties of *Vicia* and *Lathyrus* have continued to show most promise, while several perennial grasses of the genera *Agropyron, Brachiaria, Bromus, Ehrharta, Hyparrhenia,* and *Melinis* have done well at Perth or Wokalup.

At Katherine, tests in nursery rows have led to the selection of nine grass species for further trial, and species of *Stylosanthes,* including *S. gracilis, S. bojeri,* and *S. erecta* have been among the best legumes, though the length of season there is too short for their best development. Two legumes of similar habit to the peanut, *Voandzeia subterranea* and *Kerstingiella geocarpa,* gave excellent growth and yield on a single plant basis. They may be of special value for pig-feeding.

(ii) *Replicated Trials.*—A trial at Canberra designed to compare the yield and regeneration of several annual and short-lived perennial grasses with that of Wimmera ryegrass was continued. Plant mortality of most species was high during the first summer, but seedling regeneration was good. One of the most promising species at present is *Bromus coloratus,* which is productive and combines well with subterranean clover.

Further replicated trials in Western Australia have confirmed the value of *Vicia monantha* as a grain legume. It was successful wherever tried, and was the only species to succeed in places subject to severe earth mite attack.

Varieties of bulrush millet have been under trial at Katherine and Lawes. Grain yields at Katherine have been rather below those of grain sorghums, and it is considered that the plants are most likely to be useful in drier regions with a shorter growing season.

Several species of *Phaseolus,* including *P. mungo, P. acutifolius,* and *P. aureus,* proved to be admirably suited to the short hot wet season at Katherine, with attractive growth habit suited to mechanical harvesting, and encouraging yields in small replicated trials. Further varietal trials are to be conducted.

(iii) *Regional Trials.*—Regional trials of promising pasture plant introductions have been conducted at several centres in most States, usually on a co-operative basis.

The results at Melbourne have been generally similar to those at Canberra, with species of *Bromus* and *Agropyron* showing most promise among the grasses. Strip trials of these and other species have been established at Rosebud in Victoria.

Several introduced varieties of *Agropyron, Dactylis, Festuca,* and *Bromus,* which had made good growth in nursery rows, have been sown under sward conditions at Armidale, while at Trangie a similar trial has been established in co-operation with the New South Wales Department of Agriculture. *Sorghum almum,* a perennial grass which is highly regarded in parts of Argentina, has made outstanding summer growth in trials at Curlewis, near Gunnedah, but its general release will depend on the results of toxicity tests at present in progress.

A preliminary survey of the results of trials of *Stylosanthes gracilis* at numerous centres throughout northern Australia indicates that stylo does not succeed in regions subject to frost or with a growing season of less than five to six months. Further, the growth is very limited and the plants die unless the rainfall in the growing season exceeds 35 inches. These facts accord well with the distribution of the plant in South America, but its potential range may be extended by the use of other strains recently obtained there.

(*d*) *Green Manure and Cover Crops.*—A trial at Griffith, New South Wales, designed to compare the productivity of several winter-growing leguminous species has been concluded. The results indicate that none of the introduced species is equal in productivity to tick beans as green manures.

A variety of cowpea recently introduced from the Gold Coast appears promising as a green manure for use in orchards in southern Queensland, while other varieties of this species, from India, U.S.S.R., and South Africa, have shown to advantage in trials at Katherine, being high-yielding and retaining their leaves throughout the wet season.

In Western Australia, some of the introduced vetch varieties give very high green yields and should be suitable for use as green manures, while experiments have also been begun at Lawes to test their value as soil-improvement crops in southern Queensland.

(*e*) *Vegetable Oil Plants.*—(i) *Linseed.*—Investigations with linseed have formed a major activity at Lawes, and have included varietal trials conducted over several years at Lawes and at other centres in south-eastern Queensland. These have demonstrated that linseed is a potentially important commercial crop in the region, the yields comparing favorably with those obtained overseas, though fluctuating greatly from year to year. Some of the introduced varieties have consistently out-yielded the standard variety Walsh. The best-yielding varieties, however, are rust-susceptible and therefore not suitable for general cultivation, but there are also a number of rust-resistant varieties which compare favorably in yield with Walsh. These include the varieties Malabrigo, Viking, and Newland.

A progress report on the linseed experiments has been prepared for publication. Further trials are in progress.

(ii) *Soybeans.*—Soybean trials have been continued at Red Cliffs, Griffith, Lawes, and Katherine. Results at the first two centres are not yet available, and at Lawes seasonal conditions again interfered seriously with the establishment of trials. However, some recent introductions from South Africa appeared very promising in nursery rows at this centre, and work with them will be continued.

Several introduced varieties performed well in a variety trial at Katherine, the best being Otootan with an average yield of 820 lb./acre. The success of low-latitude varieties at this station justifies further trial of varieties from Rhodesia and China.

(iii) *Peanuts.*—In addition to the seed multiplication of South American varieties at Redland Bay, peanut variety trials have been conducted at Katherine, in which several introduced strains were compared with local Virginia Bunch. None of the introduced varieties appeared superior to the control, but the work will be continued, incorporating the best material from the nursery trials at Redland Bay.

(iv) *Sesame.*—A variety trial of sesame at Katherine has shown that while it grows well under the seasonal conditions at this centre, the yields (575 lb./acre for the best variety) are too low to be economic, especially having regard to the labour requirements for harvesting. Any further work will be confined to non-shattering strains suitable for mechanical harvesting.

Trials are also in progress with varieties of sunflower, niger seed, rapeseed, and safflower, the main objective with the latter being to obtain high-yielding spineless types.

(*f*) *Technical and Miscellaneous Plants.*—(i) *Guar* (*Cyamopsis tetragonoloba*).—Previous reports have drawn attention to the value of guar both as a forage plant and as a source of mucilage for use in the paper and food industries. During the year good yields of seed have been obtained in variety trials under irrigation at Red Cliffs and under natural rainfall at Katherine. In each instance the "Regular" variety gave the best results, with yields of about 1,300 lb./acre and 1,000 lb./acre respectively, but the "Erect" strain, which is commonly grown in the United States, may be favoured by closer spacing.

Laboratory tests by a leading paper company have shown that the mucilage from the seeds may be of value for the manufacture of multi-wall bags, and these tests are to be checked in a mill trial.

(ii) *Camphor Basil.*—A variety of camphor basil (*Ocimum kilimand-scharicum*) obtained from the United States has been under trial at Lawes and Katherine. Growth at Katherine was poor, and the plants suffered severely from nematodes, but those at Lawes made good growth and appeared well suited to the conditions. Two cuts of green material were made during the autumn of 1948, and gave a fresh yield equivalent to about 28,000 lb./acre, with a camphor content of 75 lb./acre. These yields are below those obtained in the United States, and the camphor content may have suffered through delays in analysing the material. The tests are being continued.

(iii) *Cereals.*—The results obtained from a cutting and recovery trial of introduced oat varieties at Kojonup (Western Australia) indicate that some of these are better general-purpose varieties for the district than any of the usual commercial types.

Cutting trials of oats and barleys are also in progress at Wokalup (Western Australia) with the object of selecting more suitable varieties for the higher rainfall areas in the south-western parts of the State.

(*g*) *Herbarium.*—During the year 3,018 specimens have been incorporated in the herbarium, making the total of numbered specimens now 18,221. Important additions to the collections include—

(i) 740 specimens, with several valuable duplicate types, collected in northern Queensland by L. J. Brass;
(ii) 620 specimens from Tasmania collected by Miss Burbidge;
(iii) several hundred Western Australian plants collected by E. T. Bailey;
(iv) about 600 specimens collected in South Australia, King Island, and Tasmania by R. A. Perry;
(v) 313 Queensland specimens obtained from L. J. Webb and the Brisbane Herbarium;
(vi) 215 South American plants collected by W. Hartley and B. Rosengurtt;
(vii) plants received from the Forest Botanist, Lae, New Guinea.

Many of the above have been mounted and laid in the herbarium, but large numbers of others still await determination, together with several parcels collected by officers at field stations. A high proportion of the time of the systematic botanist has necessarily had to be devoted to routine determinations, of which upward of 2,000 were made during the year.

Other activities during the year include progress with critical studies of the genera *Triodia* and *Poa*, a tentative key to the former genus having been prepared, together with Latin descriptions of new species. The preparation and collation of lists of important systematic botany publications held in Australian libraries is under way. It is intended to combine these lists into a catalogue which will be of great value to botanists throughout Australia.

13. KATHERINE EXPERIMENT STATION.

During the 1948-49 wet season the first experiments were conducted on the limestone red soil which is the major soil type away from the river levees. Five acres were cleared and cultivated. The preliminary experiments concerned grain sorghums, peanuts, cotton, broom millet, cowpeas, and pasture species. Yield figures are not yet available but all crop yields will be much lower than those obtained on the levee soils. A major response to superphosphate has been obtained with most crops, and a seed crop of grain sorghums failed to mature without it. A fertilizer experiment with numerous trace elements showed no major vegetative response in either grain sorghums or cowpeas.

Observations on natural pastures have shown that annual pastures are dry by the end of March while perennial species are dry by the end of May. Native species have only one major growth cycle, and mature irrespective of whether rains continue. On the other hand, some introduced species, e.g., *Cenchrus*, flower quickly, enter a second vegetative stage, and flower again. If sufficient moisture is present, three periods of vegetative growth may occur in the one wet season.

Preliminary attempts were made to introduce *Stylosanthes gracilis*, *S. sundaica*, *Panicum maximum* (guinea grass), *Cenchrus ciliaris*, and a *Pennisetum* sp. into native pastures. The grass species failed to establish but light stands of the *Stylosanthes* spp. were obtained. The most successful establishment was obtained in plots which were surface cultivated and top-dressed with superphosphate.

Experiments have been continued on the levee soil with cotton, peanuts and tobacco. Cotton has again done well and it appears that yields of 700-1,000 lb. of seed cotton per acre may be expected on this soil type. Staple is of medium length and longer than on the limestone soils.

14. Kimberley Research Station.

Investigations into the use of the Ord River flood plain have been continued at the Kimberley Research Station in co-operation with the Western Australian Department of Agriculture.

(*a*) *Wet-season Crop Plantings,* 1948-49.—The number of supplementary irrigations required to mature a normal summer crop has varied from 1 to 4. The most successful crop during 1948-49 wet season was the peanut. In one fertilizer experiment the variety Virginia Bunch averaged 1,450 lb./acre without fertilizer and 1,824 and 2,000 lb./acre respectively with 2 and 4 cwt./acre of superphosphate. In a second experiment in which the plants were damaged somewhat severely by grasshoppers, yields of 799 and 760 lb./acre were obtained from the varieties Virginia Bunch and Red Spanish respectively. In this experiment there was no increase in the fertilized plots.

The 1948-49 wet season cotton crop grew well and gave promise of a high yield but a severe late storm caused the first crop of bolls to shed. The crop flowered a second time and produced a crop of the order of 300 lb. of seed cotton per acre. Insect pests were severe during the wet season.

The grain sorghum variety Hegari produced up to 50 bus./acre with 4 cwt./acre of superphosphate and 46 bushels with 2 cwt., but only 26.5 bushels without fertilizer. A sorghum variety experiment was severely damaged by birds when nearing maturity and averaged only 22 bus./acre.

Both cowpeas and maize made good vegetative growth. However, the cowpeas were severely damaged by grasshoppers and the final yield of grain or green fodder was low. The maize failed to pollinate satisfactorily.

So far it has proved impracticable to obtain a satisfactory yield of rice owing to depredations by cockatoos, ibis, and finches.

(*b*) *Dry-season Crop Plantings.*—Dry-season crops have required 8 to 11 irrigations to bring them to maturity. All the above-mentioned crops were planted during the dry season of 1948 and the plantings have been repeated this year. Owing to the delay in bringing new land under irrigation the 1948 plantings were made rather late and the cotton and peanuts did not reach full maturity before the break of the wet season. In consequence, yields were lower than can be normally expected. Under these conditions the maximum yield of cotton was 256 lb./acre of seed cotton produced by a fertilized crop of the variety Miller Lot I. Insect pests were not troublesome until the break of the wet season.

The yield from fertilized plots of peanuts for the two varieties Virginia Bunch and Red Spanish were 750 and 670 lb./acre respectively.

The highest yield of grain sorghum was from the variety Hegari which produced 29 bus./acre with fertilizer.

The current dry-season plantings have been made much earlier in the season and should have ample time to mature.

(*c*) *Dry-land Agriculture.*—All the major crops have been planted under dry-land conditions and in most cases the yields have been unsatisfactory. However, during the wet season just concluded the peanut crop made very good growth and yields of 1,106 and 991 lb./acre were obtained with 1½ cwt./acre superphosphate from the varieties Red Spanish and Virginia Bunch respectively.

(*d*) *Pasture Experiments.*—The pasture experiments have generally been more successful than the crop experiments. Para grass, Rhodes grass and paspalum have continued to make satisfactory growth in large plots. Ten acres of pastures are available for grazing during the current dry season, and it is hoped to obtain data on annual live-weight increases. The testing of pasture grasses and legumes has been extended. Several grasses, including guinea grass, elephant grass, *Cenchrus ciliaris* Type B, *Paspalum scrobiculatum*, and *Andropogon gayanus* have made promising growth during the first year of establishment. Of 20 legumes planted few have shown any promise. In mixed pastures lucerne has been selectively attacked by grasshoppers and has failed to survive the humid wet season on the heavy soil. *Phaseolus lathyroides* has spread somewhat in the pastures but a large proportion of the plants have developed the witches' broom disease. *Clitoria ternata* has done well during the first year in nursery plantings. The behaviour of peanuts in this environment suggests that pasture types of this genus may be worth investigation.

(*e*) *Fertilizer Experiments.*—Numerous fertilizer experiments have been conducted on cotton, peanuts, and grain sorghum. Major responses have been obtained from superphosphate and it would appear that the general use of this fertilizer would be a necessity for crop or pasture production. Responses to potash have been obtained with peanuts but not with grain sorghums. In spite of adequate applications of phosphate, nitrogen and potash, and ample irrigation water to supplement deficiencies in rainfall, yields of some crops, grain sorghum in particular, have not been as high as might be expected. The fertility status of this soil and the problem of obtaining better adapted crop varieties will be further investigated.

15. North Australia Regional Survey.

The field survey of the Barkly region was continued during the dry season of 1948, when an additional 5,000 miles of land traverses was made, extending from Carrandotta in the south-east to Burketown and Borroloola on the Gulf, and Tennant's Creek and Daly Waters in the west. A total area of approximately 120,000 square miles of country was traversed in this region, including not only the area of heavy soil commonly known as the Barkly Tableland but also the country between this and the Gulf of Carpentaria, and the adjacent desert to the south.

The interpretation of aerial photographs has continued and geomorphological, land system, and geological maps are nearly complete. The Director of National Mapping and his staff collaborated in assembling and marking aerial photographs for making traverses and in preparing the final maps to accompany the reports. In addition to a map covering the whole region, on a scale of 16 miles to the inch, these surveys will make possible the publication of twenty land system maps on a scale of 4 miles to the inch. The position and nature of all bores have been plotted on a separate map, which in conjunction with the land system map will indicate where further development is possible.

The plant specimens collected on this survey number over 1,000 and six samples of each have been mounted for distribution. The herbarium determination of the specimens has been continued and so far about 400 species have been identified.

Soil samples collected on the survey have been sent to the Division of Soils for chemical and mechanical analysis. A limited number of pasture samples has already been analysed for nitrogen, phosphorus and potassium.

The report of the first region surveyed, the Katherine-Darwin region, has been prepared for publication.

Survey of a third region has just begun. This includes the watersheds and basins of the river systems in the Ord River-Victoria River region and covers approximately 75,000 square miles.

16. Fruit Investigations.

Work on vine and citrus fruits in progress at Merbein and Griffith is outlined in Chapter IV., and investigations into insect pests, such as mites and citrus red scale, are described in Chapter IX.

(*a*) *Apple and Pear Investigations at Stanthorpe, Queensland.*—The past year was notable for a late severe frost on the night of 22nd-23rd October, when grass temperature readings of 18° F. were recorded. The apple trees had set their fruit but in common with a great number of orchards in the district the experiment trees suffered a complete loss of crop.

Further supplies of Merton apple stocks were successfully propagated for trial and new woolly aphis immune apple stocks recently obtained from England have been budded to Jonathan and are ready for trial. Sufficient pear stocks have also been propagated to plant an additional experiment. These stocks include several readily propagated types selected from a collection made from Victorian orchards. Incidental studies have shown that Delicious at Stanthorpe requires cross pollination. Jonathan gave good results. Studies are being made to test the hypothesis that poor growth of young apple trees planted on land which has carried apples is associated with toxic substances in the soil originating from the previous planting.

Considerable progress has been made in the preparation of new land for experiment plots and establishment of facilities which will increase the efficiency of orchard management and experiment at this Field Station.

(*b*) *Apple and Pear Investigations in Tasmania.*—The officer concerned with the investigation of the problems of physiological storage disorders in apples and pears has resumed his work after returning from a period of secondment to the Department of Commerce and Agriculture as Fruit Officer in London. An account of the results of the studies made since 1932 is being prepared for publication. The programme will now be restricted to a study of the effect of nitrogen upon the keeping quality of applies. This will be investigated in relation to apple and crop size, which the previous work showed were the outstanding factors affecting storage capacity. In addition, investigations are being commenced which aim to determine the fertilizer requirements of apple trees by means of chemical analysis of leaves and tree parts.

(*c*) *Gummosis of Apricots.*—In 1945, as a result of a decision by the Australian Agricultural Council, an Advisory Committee consisting of representatives from C.S.I.R.O. (Division of Plant Industry), the Department of Agriculture of South Australia, the Department of Agriculture of Tasmania, and the Waite Agricultural Research Institute, Adelaide, was appointed to examine the problem of dieback or gummosis of apricot trees which was reported to be causing considerable loss both in South Australia and Tasmania. This Committee recommended that a thorough survey of the occurrence of the disease should be made and data collated with respect to factors affecting its incidence. In 1947 C.S.I.R.O. appointed an officer to make this study under the general guidance of the Advisory Committee and the direct supervision of the Chief Plant Pathologist of the Waite Agricultural Research Institute.

The field survey has been completed and the main conclusions are as follows:—The immediate cause of the disease appears to be the fungus *Cytosporina*. The number of trees infected is very high in the non-irrigated areas of both South Australia and Tasmania (50 per cent. and over), but is less in the irrigated areas of South Australia. The disease also occurs in the southern areas in Victoria and was found in the Goulburn Valley and the Murrumbidgee Irrigation Areas, but does not constitute a serious problem there. Severity of the disease increases with the age of the trees and it is estimated that almost a third of the apricot trees in Tasmania and non-irrigated South Australian orchards have been destroyed or are very badly affected by the disease. No very marked association was found between the incidence of the disease and variety, rootstock, fertilizer treatment, pruning, or ordinary schedule sprayings, although some slight correlations require further investigation. There is a good general association, however, between the incidence and severity of the disease and soil water conditions. The actual manner of infection and the biology of the host-fungus relationship present a number of mycological problems. Further investigation will aim to solve these problems and study the relationship observed between soil water conditions and the incidence of the disease.

17. Drug Plants.

Research has been continued along the lines previously indicated on the opium poppy as a source of morphine, on *Duboisia* spp. as sources of hyoscine and atropine, and on *Eucalyptus macrorrhynca* as a source of rutin. Good progress has also been made in the investigation of the chemical and pharmacological constituents of other native plants.

(*a*) *Opium Poppy.*—The opium poppy breeding work has reached the stage when definite conclusions may be drawn and results will be published shortly. Improvement in agronomic characters has been achieved and varieties better adapted to direct extraction of morphine from the dry capsule and to cultivation under winter rainfall conditions in south-eastern Australia have been developed by hybridization. Improved types have yielded 50 per cent. more morphine per acre than the variety grown commercially during the war. Steps are being taken to build and maintain small seed stocks of these new varieties. Further study of morphine assay methods in plant material has shown that the method in use for the work is reliable. Though giving lower results it checked well with the method recently devised by the United States Bureau of Narcotics and the United States Department of Agriculture.

(*b*) *Duboisia spp.*—Observations and assays have been continued on the selected progenies of *D. myoporoides, D. Leichhardtii,* and intermediate types for the selection of superior types for hyoscine and atropine production under cultivation. Progress has been made in devising new assay methods and the examination of larger samples. Using high hyoscine samples numerous assay trials were run in an attempt to achieve the complete separation of hyoscine and hyoscyamine and their subsequent quantitative estimation by titration with picric acid in chloroform. The percentage of hyoscine can be determined satisfactorily in samples in which hyoscine is the dominant alkaloid. Previous measurements of total alkaloid seem, however, to have been too high and attention is now particularly directed to developing a method which will give a reliable figure for both hyoscine and total alkaloid. A method for separating mixtures of hyoscine and hyoscyamine by a partition chromatogram on a buffered column of Kieselguhr promises to be useful.

An account of the life histories of *D. Leichhardtii* and *D. myoporoides* is to be published shortly.

(*c*) *Rutin.*—Investigation into the variation of the rutin content of the leaf of *Eucalyptus macrorrhynca* has been continued and variation in content studied with relation to age of leaf, time of season, &c. Results previously reported have been confirmed and details are soon to be published. Leaf of *E. youmani* has been found to contain rutin in amounts comparable with *E. macrorrhynca,* but none of the other species tested contained any.

(*d*) *Survey of Native Plants for Sources of Substances of Pharmocological Value and Chemical Interest.*—The scope and nature of this survey have been described previously (*vide* Annual Report 1947-48). The Universities of Sydney, Melbourne and Queensland have been co-operating with the Organization in carrying it out.

In January, 1949, a second conference of research workers concerned in this co-operative project was held. The conference was attended by 26 delegates from eleven organizations. Results obtained by collaborating workers are published as reports of the Institutions to which they belong and/or in appropriate scientific journals. Arrangements were made for the establishment of a permanent Standing Committee to compile an Australian Phytochemical Register. The chemical phases of this work with which C.S.I.R.O. is directly concerned are reported by the Division of Industrial Chemistry (*see* Chapter XVI., Section 7 (*c*)).

18. Tobacco.

In co-operation with the Queensland Department of Agriculture and Stock, field experiments were continued in the Ayr district on the Queensland Tobacco Experiment Station established at Claré. Particular attention was given to water requirements and varietal characteristics, and high yields of good-quality leaf were obtained. Commercial production in this area has begun and seems assured of a successful future.

At Katherine, the results of preliminary investigations over the past two years indicated that seasonal conditions for production under irrigation were most favorable during the June-September period. Accordingly, more detailed work is now being done on plant requirements at that time of the year.

Progress has been made with disease investigations. The entomologists concerned have established that yellow dwarf virus of tobacco has a wide host range. This is a factor of importance when means of control are being considered.

(*a*) *Irrigation Experiments.*—An investigation of the water requirements of tobacco grown during the dry season in the coastal areas of North Queensland was undertaken at Clare. Rainfall during the growing season is five to six inches, most of it occurring toward the end of the period, and during 1948 repeated irrigations were necessary to maintain plant growth. There were two experiments each occupying an area of about one acre of the levee soil of the Burdekin River. Growth and yield when irrigation water was applied in furrows and by sprays were compared, sufficient water being applied by both methods at weekly intervals to provide optimum growth requirements. Differences between treatments were not significant but the experiment showed that modifications in cultural procedures were necessary to ensure adequate watering by furrows during plant establishment. In the second experiment there were eight spray treatments: weekly applications of .5, 1, 1.5, and 2 inches respectively throughout the growing season, and four treatments with the same total quantities as each of the previous treatments but applied weekly in quantities that were expected to meet the requirements of the growing plant. Total applications, including the pre-treatment waterings, varied from 10 to 29.5 acre inches. From the appearance of the plots during the season, the total requirements for satisfactory growth during 1948 was approximately 20 acre inches plus 3–3.5 inches to ensure establishment of seedlings in the field. Good yields were obtained with less water but the tobacco that received only 10 inches was stunted and failed to ripen satisfactorily.

(*b*) *Genetics.*—Tobacco varieties grown in Australia were developed for production in areas with an environment different from that in which tobacco is grown in this country. The reaction of 65 varieties and strains of tobacco to local conditions was investigated in growth studies on the Queensland Tobacco Experiment Station at Clare. Most of the varieties were obtained from similar climatic regions and comprised 22 from India, six from Ceylon, four from Burma, and others from the Celebes, Nyasaland, Porto Rico, Guatemala, the United States of America and Australia. Some showed characteristics of value in a plant breeding programme but many of them, as was expected, were not of the flue-cured type. Pusa type 142 and Mustaphabad, both from India, were outstanding for width and number of leaves respectively. Another characteristic that may be of importance in North Queensland was the relative freedom from damage by insect pests of some varieties. An adjunct to the plant improvement programme is the maintenance of seed supplies and during the year approximately 600 varieties and strains were tested for viability. A seed production plot containing 109 varieties was established at Canberra. Lists containing particulars of 436 varieties and strains now available were issued to State departments concerned with tobacco production.

(*c*) *Diseases.*—Yellow dwarf of tobacco was observed for the first time during 1948 in North Queensland. It is also present in Western Australia but is not of importance in either area. Big Bud is present in all tobacco areas but is seldom of importance. The study of these two diseases was continued under greenhouse conditions, attention being given to conditions under which infected plants develop symptoms. The interval between infection and appearance of the disease varies from about two weeks to twelve months and this irregularity is a serious limiting factor in greenhouse work. The effect of age of plant and period of the year in which infection occurs is being investigated. Field observations in the occurrence of Big Bud in tobacco plants infected by yellow dwarf were confirmed in greenhouse tests. In grafting experiments, potatoes rarely became infected but natural infection of potato by Big Bud was confirmed in one instance. All attempts to transmit yellow dwarf by dodder failed, but five different species of plants were infected with Big Bud by this means. Attempts to transmit Big Bud to Cranberry by dodder and the insect vector were unsuccessful. Replicated plots to determine the effect of plant spacing and sprays on occurrence of yellow dwarf of tobacco were established at Canberra but seasonal conditions did not favour natural infection and results were inconclusive.

In preliminary tests the Victorian variety Hickory Pryor was much more susceptible to black root rot (*Thielaviopsis basicola*) than four resistant varieties obtained from other countries.

(*d*) *Chemistry.*—During the period under review a laboratory was established at Canberra. Pending the arrival of equipment, the chemist studied procedures employed in other laboratories and in the field, and obtained samples for investigation. By courtesy of the Cawthron Institute, New Zealand, several months were spent in association with chemists engaged in tobacco research at that institution. This was followed by a similar period in a modern tobacco factory and the examination of conditions under which tobacco is produced under irrigation in North Queensland.

(*e*) *Physiological Investigations.*—(i) *Water Requirements of Tobacco.*—Attention has been primarily devoted to a study of the growth and development of the tobacco plant when grown at different levels of soil moisture and subjected to varying drought treatments. These treatments consisted of a period of drought (i) in the midst of the vegetative growth stage, (ii) at emergence of the inflorescence buds, and (iii) a combination of the first two treatments.

There was a progressive reduction in the total leaf weights as the level of soil moisture was reduced. The yield of leaf also appears to have been lowered by each of the restricted treatments, though it is doubtful if the reductions in the yields are significant.

(ii) *Suckering.*—The reactions of four growth-regulating compounds on the development of axillary growth (suckers) were observed.

The differences between the treated and untreated plants indicate the possibility of the axillary growth being inhibited.

(*f*) *Other Investigations.*—At Katherine, experience gained during the past two years has demonstrated the necessity for careful attention to time of planting in order to avoid the excessively hot months October-December and the generally difficult conditions experienced during the wet season. Seed was sown in April, 1949, and seedlings transplanted in June, the objective being to complete harvesting early in October. Experiments to determine water and fertilizer requirements were also established at the Katherine Experiment Station. There were six watering treatments with rates varying from .5 to 2 acre inches per week and seven fertilizer treatments.

At Clare, experiments on the control of nematodes in seed-bed soil by chemical treatments were established in co-operation with the Queensland Department of Agriculture. There were eight treatments and the seed-beds will be ready for sowing in July, 1949.

19. Plant Diseases.

(*a*) *Virus Investigations.*—(i) *Spotted Wilt in Potatoes.*—Further studies were made of the extent and nature of transmission through seed tubers. Studies of the thrips population of potatoes were made by mass collection. Tanglefoot traps were used to obtain a record of population activity.

Examination of data is not yet completed, but sufficient has been done to indicate that *Thrips tabaci* Lind. is the second most numerous species in the area (the population is predominantly *Thrips imaginis* Bagnall) and is the only known vector species present. Again this season there was virtually no field transmission of the virus. With the exception of studies of the thrips vectors, work on this problem has been completed and is being prepared for publication.

(ii) *Spotted Wilt in Tomatoes.*—In the summer of 1948-49 work was confined to the testing of the resistance of certain hybrids received from Dr. F. O. Holmes, of Princeton, United States of America. The light field incidence of spotted wilt made these tests of little value, but seed has been collected for testing in other parts of Australia.

(iii) *Potato Virus X.*—An experiment to determine the relative rates at which virus X will spread into FX stocks of the varieties Factor (Up-to-Date), Snowflake, Bismark, Sebago, and Katahdin was set out in the field at Dickson, Australian Capital Territory. The unit plot consisted of eleven plants, the centre plant being inoculated to serve as a source of virus X. The tubers of each plant will be inoculated to *Datura stramonium* during the winter of 1949 to determine the spread of Virus X from plant to plant.

(iv) *Witches' Broom Virus of Lucerne.*—Attempts to study the host range of this virus by interspecific grafts and continued attempts at dodder transmission have been unsuccessful. Material is now being accumulated for an investigation of the anatomical effects of the virus in the lucerne plant, in relation to seasonal recovery.

As a result of experience in field surveys of the virus it has been concluded that the only way to get reliable counts of disease incidence is to peg fixed traverses and examine the same plants each time. This is because the greatly varying size and position of offshoots of lucerne crowns make it extremely difficult to distinguish individual plants. Accordingly series of fixed traverses have been pegged at five widely separated sites for long-term observation of the effect of the disease on the stand of lucerne.

(*b*) *Potato Diseases.*—(i) *Common Scab* (*Actinomyces scabies*).—Field trials of varietal resistance to this disease included plots at Canberra, Lawes (Queensland), Rendelsham (South Australia), and Mowbray Swamp (Tasmania). As in the previous season, there was much variation in the order of susceptibility of the same varieties in different localities; however, Cayuga, Ontario, and 1537-12 were highly resistant wherever grown during the past two seasons, and variability in resistance was much more marked among the less resistant varieties than among the highly resistant. No resistant variety equalled Late Carman, Factor, or Sebago in yield.

Three varieties were inoculated with each of three scab isolates separately in pots of limed sterilized soil, to determine whether differences between races of *A. scabies* might be responsible for certain inconsistencies in the results of varietal resistance trials in different localities in 1947-48. The results did not support this hypothesis. Sulphate of potash at the rates of 2.5, 5, and 10 cwt. per acre had no significant effect on the severity of scab on Bismark potatoes on a calcareous peat soil of pH 6.8 at Mowbray Swamp, Tasmania.

(ii) *Rhizoctonia Scab.*—Attempts to determine whether there is any real difference between potato varieties in resistance to *R. solani* were continued. Four commercial and two Commonwealth Potato Collection varieties were selected on the results of previous field tests from 54 commercial and 25 C.P.C. varieties. Of these six varieties, two commercial and one C.P.C. variety were judged to be among the most resistant in previous tests, and the remaining three among the most susceptible. Six replications of each were grown in a field trial in artificially inoculated soil at Canberra. Medium Brownell and C.P.C. 1417 (a clone of *Solanum andigenum*) repeated their previous resistant reactions, but differences between the average disease ratings for these and for the susceptible varieties were barely significant. Ratings were based on the severity of underground injury to sprouts and stolons, assessed when the plants were dug at flowering time.

Brownell and C.P.C. 1417 were also comparatively resistant to sprout injury in pots of artificially inoculated soil, but Arran Banner, one of the most susceptible in field tests, was less affected than Brownell in these tests. C.P.C. 1417 was the only one of a number of varieties tested, of which young shoots detached before emergence from the soil showed any sign of resistance to rotting by *R. solani* in pure culture on mineral salts agar.

Under these conditions, Brownell shoots rotted almost as rapidly as those of Red Warba, which appeared the most susceptible of all varieties tested in the field or in pots of soil. There was much inconsistency between the results of the three methods of attempting to determine susceptibility, and also between comparable replicates in a single experiment by any one method. It is not thought that any varietal differences in susceptibility hitherto observed are marked enough or consistent enough to warrant an attempt to make use of them in breeding for resistance to *R. solani*.

(iii) *Late Blight* (*Phytophthora infestans*).—A number of resistant hybrids introduced by the Vegetable Section from Scotland were multiplied in isolated field plots for future testing. Several isolates of *P. infestans* from diseased tubers collected in New South Wales, Tasmania, and Victoria are being maintained in live tubers.

(*c*) *Tomato Diseases.*—A nutritional deficiency condition of young tomato plants grown on Soil Type No. 1 from the Dickson Experiment Station, Australian Capital Territory, has been investigated and shown to be due to an acute deficiency of phosphate. The symptoms were more severe than those usually described and in addition to stunting and excess anthocyanin production a constant necrotic reaction not previously recorded in the literature was shown by all plants. Older leaves were affected first, the condition subsequently appearing on progressively younger leaves.

20. VEGETABLES.

The work on vegetables in progress at Merbein and Griffith is reported in Chapter IV., Section 2 (*g*) and 3 (*e*), and investigations into entomological pests are outlined in Chapter IX, Section 6.

(*a*) *Virus Resistance in Potatoes.*—Work on combining resistance to the potato viruses A, X, Y, and leaf roll in hybrids of good agronomic quality is being continued. Agronomic studies and development of promising resistant hybrids are being undertaken in co-operation with officers of the Tasmanian, Victorian, Western Australian, and New South Wales Departments of Agriculture.

Use has been made of potato seedlings for the separation of strains from a virus X complex and the reaction of these strains on various indicator plants has been studied. A study has been made of some of the factors affecting the appearance of localized and systematic necrotic reactions to virus Y in the potato. A modified technique for the identification of leaf-roll-infected potato plants has been developed to a quantitative basis. This test is being used to measure the leaf-roll resistance of potato hybrids.

(*b*) *Spotted Wilt Resistance in Tomatoes.*—A high degree of resistance to the tomato spotted wilt virus has been located in a line of *L. pimpinellifolium.* A backcrossing programme is now in operation to incorporate this resistance in large-fruited types of commercial value. Field trials under epidemic conditions have confirmed the resistance of these hybrid lines.

(*c*) *Fusarium Wilt Resistance in Tomatoes.*—Tomato hybrids field immune to *Fusarium* wilt have been developed. Agronomic suitability for both field and glasshouse use is being tested in co-operation with the State Departments of Agriculture.

(*d*) *Peas.*—Work has been continued on the study of resistance to *Ascochyta pisi.* A study of the method of inheritance of resistance in hybrids between the variety Austrian Winter and commercial pea varieties has been completed and prepared for publication. The backcross programme to incorporate the resistance of the Austrian Winter parent in a garden pea is being continued in association with the Victorian Department of Agriculture.

No variety has been found with high resistance either to *Ascochyta pinodella* or *Mycosphaerella pinodes,* the other two diseases of the Ascochyta group.

The testing of new varieties for resistance to bacterial blight (*Pseudomonas pisi*) is being continued, but no variety has shown evidence of high resistance to this disease. The relationship between frosting of pea plants and the manifestation of symptoms of bacterial blight is being investigated.

(*e*) *Beans.*—The examination of varieties for resistance to halo blight (*Pseudomonas medicaginis* var. *phaseolicola*) and to American blight (*Xanthomonas phaseoli*) is being continued. Some strains of the variety Red Mexican are highly resistant to halo blight, but no variety has shown consistent resistance to American blight when tested with a number of strains of this organism.

A survey of bean varieties for resistance to angular leaf spot will be commenced as soon as a satisfactory testing method has been developed.

21. FERTILIZER EXPERIMENTS IN PINE PLANTATIONS.

To determine the best procedure for applying phosphatic fertilizer to newly planted *Pinus caribaea,* an experiment was begun at Woodburn, on the south coast of New South Wales. This includes five replications of (1) control; (2) ground rock phosphate broadcast at each of two rates of application; (3) rock phosphate concentrated around each tree; (4) superphosphate broadcast; (5) superphosphate concentrated around each tree.

No results are yet available. Annual measurements were continued in the experiments begun several years ago in older trees.

22. MINERAL NUTRITION OF PLANTS IN THE NINETY-MILE PLAIN, SOUTH AUSTRALIA.

Investigation of the mineral nutrition of plants in the Ninety-mile Plain, South Australia, which has been undertaken within the Division of Biochemistry and General Nutrition, has been extended to cover a number of the prevalent soil types.

The early experiments which demonstrated that an application of zinc and copper together with superphosphate was essential for the successful establishment of subterranean clover on one of these soils, the Laffer sand, have been described in previous reports. Regular collection of yield data from these experiments was discontinued in 1946, but the original experimental pastures have been top-dressed annually with superphosphate and have been kept under observation. They have shown no evidence of decline although zinc and copper have not been applied since the initial dressings were given at seeding in 1944. The pastures at present carry an excellent cover of Bacchus Marsh variety of subterranean clover and phalaris, together with a small quantity of lucerne.

The Laffer sand, in which these initial experiments were carried out, is a grey siliceous sand underlain at a depth of about 15 inches by sandy clay over limestone. It supports an association of stunted heath plants. The research has been extended to other soils found in the Ninety-mile Plain with results as promising as those obtained on Laffer sand. Attention is being given at present to areas of the heath where the clay and limestone horizons occur at depths exceeding three feet, and to mallee-broombush areas where a shallow surface sand is underlain by a horizon of clay many feet in thickness.

The deficiency of zinc and copper has been found to range from a particularly acute form in some of the deeper heath sands, to an incipient form in some of the mallee-broombush soils. Phosphorus and nitrogen deficiency prevails in all these soils, but wherever the Bacchus Marsh variety of subterranean clover has been sown with superphosphate fortified with zinc and copper, its establishment and performance have been most satisfactory. No other deficiencies have become apparent up to the present time.

Following the demonstration that proper manurial treatment of varieties of legumes adapted to the environment will transform this region economically from virtual waste to valuable pasture land, the demand for properties has become considerable. Extensive clearing and cultivation programmes are already under way. The Division of Biochemistry and General Nutrition is, as far as possible, keeping in touch with these developments, which have been based on the results of its experimental work.

The profiles and the natural vegetation of these soils may vary widely. The soils that carry a stunted heath vegetation are obviously different, for example, from those that carry mallee (*E. incrassata*) and broombush (*Melaleuca* spp.). However, there are many subtle differences, both in the soils and in the natural vegetation. These are difficult to define and to appreciate as their significance is not immediately apparent, and there is no fund of experience in this vast unoccupied territory to draw upon. A detailed ecological study of part of the County of Buckingham, as a first step towards a better understanding, was initiated in 1949 in co-operation with the Botany Department of the University of Adelaide. This study has already proved its practical worth by relating certain vegetation associations and soil types, and by clarifying the position in respect to the agricultural possibilities of particular localities.

23. Rubber (Guayule) Investigations.

These investigations, which have been carried out within the Division of Soils, are nearing a stage where it will be possible to draw conclusions about the behaviour of the plant under varying conditions of growth as governed by climatic conditions and intermittent water supply, both under natural rainfall and in irrigated areas. The field work has now been concluded after a period of about seven years, but a considerable amount of laboratory work has yet to be carried out.

The plants in most of the areas are showing signs of maturity or at least some alterations in growth activities, in that much dead wood is appearing in the outer and lower portions of the plant. There is, however, no definite indication that rubber accumulation has ceased. In important areas the progressive increase in weight and rubber accumulation has been followed at three-monthly intervals from early stages of growth and at the conclusion of the laboratory work valuable data on the behaviour of the plant should be available.

Analytical results on plants at five years of age showed 126 g. of rubber per plant at Loxton and 90 g. per plant at Loveday, both plots being under irrigation. At Loveday, without irrigation since September 1945, the result was 49 g. per plant as against 80 g. per plant at Morphett Vale. Morphett Vale is in a colder, wetter climate than the other plots above, and this plot has never been irrigated. The latest results of analysis available are: Loxton (6 years of age), 135 g. per plant; Loveday ($6\frac{1}{4}$ years of age), 129 g. per plant; and Morphett Vale (6 years of age), 84 g. per plant. The figure obtained at Loxton indicates a return of 1485 lb. rubber per acre allowing one plant per square yard.

The analytical work on samples of guayule from Canberra, Australian Capital Territory, and Lawes, Queensland, under the control of the Division of Plant Industry, has now been concluded.

24. Trend in Yield in the Wheat Belt in South Australia.

In the previous report mention was made of an investigation being undertaken within the Section of Mathematical Statistics of the trend in yield throughout the wheat belt of South Australia during the period 1913-37. As a natural outcome of this work, the analysis has been extended to cover the period 1896-1941, the basic territorial unit used for assessing yield being the hundred, the mean area of which in South Australia is approximately 118 square miles. The elimination of phosphorus as a limiting factor in the yield coincided with the beginning of this new period, so that in classifying the forms of trend observed it was convenient to divide the hundreds into two groups according to whether they were opened for cultivation before or after the advent of superphosphate. It has been established that the trends in yield are intimately related to the nitrogen status of the soils under the exploitative systems of cropping generally employed.

The wheat belt is broadly divisible into three parts:

(1) Sandy, stony, and mixed mallee soils and related types in which nitrogen becomes limiting after 20-40 years of cropping, and yields subsequently decline owing to exhaustion of the reserves.

(2) Loamy mallee soils and red brown earths, where yields increased over the period 1896-1941, but at diminishing rates as nitrogen becomes limiting.

(3) Sandy and loamy mallee and transitional mallee-solonetz soils, where yield increases linearly throughout, mainly because exploitative cropping has not been in progress long enough to make its influence apparent. These regions constitute only a small proportion of the total area.

To investigate yield trends, allowance had to be made for variations in the seasons, and consequently, as a by-product of the analysis, a considerable amount of information was obtained on the relationship between yield and rainfall. The quantitative effects on yield of autumn, winter, and spring rains have been assessed and related to soil type and general cropping practices in each district. These findings have been checked for a number of representative centres in the wheat belt, by analysis of yields obtained from government experimental farms or private farms where the exact conditions of cropping are known, and the full set of results substantiates completely those obtained in a previous investigation.

IV. IRRIGATION.

1. General.

The Organization has two Irrigation Research Stations, the Commonwealth Research Station (Murray Irrigation Areas) at Merbein on the Murray River in Victoria, and the Irrigation Research Station (Murrumbidgee Irrigation Areas) at Griffith, New South Wales. Both are situated in the midst of important irrigation settlements and keep in close touch with the settlers.

Research into soils and their behaviour under irrigation has been carried out both at Merbein and at Griffith, in close co-operation with the Division of Soils. Much of the work at these stations, which is reported separately in the remainder of this chapter, is directed towards problems of the region in which they are situated.

Studies on irrigated pastures were carried out at Deniliquin, New South Wales (*see* Chapter III., Section 5*b*), and Ayr, Queensland (*see* Chapter III., Section 10). The water requirements of tobacco were investigated at Clare, Queensland (*see* Chapter III., Section 18*a*).

2. Commonwealth Research Station (Murray Irrigation Areas), Merbein, Victoria.

The chief research projects of the Merbein Station are the irrigation of light-textured soils used for horticultural plants; the preservation of soil fertility, and in some areas the reclamation of the soils; a study of the relationships of soil and plant under irrigation, including growth records; the reaction of horticultural plants to pruning; and the processing and preservation of horticultural products.

Financial contributions to the work of the station have been on a high level for over twenty years and have recently increased. Contributing bodies include the Australian Dried Fruits Control Board, the Mildura Packers Association, and the Renmark Irrigation Trust.

(*a*) *Irrigation and Reclamation.*—Surveys have been made of many irrigation areas in regard to their reclamation requirements.

The Renmark district of South Australia is completely drained, and salt and seepage are affecting the health of trees and vines. The smaller settlement of Lyrup, South Australia, in a similar irrigation environment, is also exhibiting signs of deterioration. In the Berri and Barmera districts of South Australia, agricultural drains of standard design are being constructed by the State Government. Special features are the disposal of the water by pumping into surface drains, and in some localities natural aquifers associated with shallow limestone horizons in the subsoil.

The Cohuna district and also the district of Tyntynder, near Swan Hill, are pasture areas in which remedial measures are limited to surface drainage and to sound irrigation and pasture establishment. Surveys have disclosed widespread accumulation of subsurface free water in both these areas, with damage caused by seepage. The general conclusion is that disposal of subsoil water is not economical for pasture areas, but further investigations are contemplated.

For work in connexion with the measurement of irrigation water a gauging unit for the calibration of water meters has been completed. A meter, consisting of a 12-in. diameter rotor operating a counter and working in a 6-ft. length of 15-in. diameter pipe, has been calibrated and found to give satisfactory measurement down to a minimum flow of 1 cusec. The rotor and counter can be quickly fitted to a pipe by being merely slipped into place.

Plans have been made and materials are being collected for the establishment at the station of a spray irrigation and testing area, which will provide for examination of spray irrigation designs. Provision for variable pressure has been included. A survey of the station area has been completed and a large-scale plan (40 feet to 1 inch) has been drawn for the recording of installations and of the experimental uses of various areas year by year. Infiltration tests have been continued.

Drainage and reclamation work at Renmark and Curlwaa on river flat soils has proceeded. Further examinations of existing tile drainage in the heavy textured soils have confirmed that agricultural drains are ineffective in reducing water table levels for the major soils of this area. A type of test well or piezometer new to this area has been used at Renmark. It consists of a ½-in. diameter drawn steel tube either fitted or driven into the ground to depths from 6 to 40 feet and developed with a jet of water from a copper tube. The wells are read by means of a battery, galvanometer, and insulated length of calibrated cable, contact with the ground water completing the circuit and being indicated by the galvanometer.

The Mines Department of South Australia sank two 8-in. bores in the Renmark Area, one to 230 feet and one to 80 feet. The deep bore showed that water pressures in underlying limestone were too great to allow gravity drainage from the surface into the limestone. Both bores showed a layer of sand from a depth of 25 to 80 feet. In April, a screen and Pomona pump were fitted to the 80-ft. bore. The bore has since been delivering ½-cusec. water flow of 4 per cent. salt content and eight parts per 1,000,000 boron, and has lowered the water table 5 feet at a distance of 15 chains from the bore.

An 11-ft. deep timbered well at Curlwaa has been fitted with a pump by the Water Conservation Irrigation Commission. The well has given a flow of 200 gallons per hour and its reclamation effects are being observed.

(*b*) *Land Use.*—Soil survey work is limited to small areas, to assist the Division of Soils. The field work in an area of 1,000 acres designed for vegetable production has been completed at Buronga, New South Wales, adjacent to Mildura. In the Goodnight settlement in New South Wales, an additional area of 400 acres of orchard and vineyard plantings has been surveyed to define the types in reference to agricultural drainage.

Initial steps have been taken to survey citrus plantings in the Merbein area.

In the Wakool area, Riverina, examination of pasture production under irrigation as influenced by soil types has been continued, and an investigation to determine the value of precropping with rice is in progress. In the Red Cliffs area, drainage waters are used for pasture production and salt surveys have been made to determine the long-term effects of applying irrigation water containing appreciable quantities of injurious salts.

In the Woorinen area, Victoria, there is evidence of decreased production attributed to deterioration of the heavier-textured soils under irrigation. Soil ameliorants used comprise gypsum, sulphur, and various fodder and pasture crops. A replicated trial for long-term examination has been commenced.

(*c*) *Horticulture.*—The study of crop potential and yield variation of sultanas was continued. For several seasons the buds from a sample of sultana canes have been microscopically examined in May to determine the percentage of fruitful buds, i.e., buds containing bunch primordia. This gives an estimate of the fruitfulness of the canes retained to carry the next season's crop. The data for 1946-48 have been analysed statistically. There are highly significant differences in fruitfulness between seasons, between the vineyards from which the sample was taken, and between bud positions on the cane, and also a highly significant interaction between seasons and vineyards. The figures show that the percentage fruitfulness for this year is about twice that for last year and that a good showing of fruit can be expected on sultana vines in the coming season (1949-50).

After bud burst in spring each year, an examination has been made of the vineyards sampled in May, and records taken of the number of buds which have produced shoots and the number of shoots bearing bunches. There appears to be evidence to show that preferential bursting occurs. Last year when the percentage fruitfulness was very low, the percentage of fruitful buds that burst was considerably higher than for unfruitful buds—96 per cent. against 56 per cent. In 1946 and 1947, when the percentage fruitfulness was about average, the difference was not so great—75 per cent. to 61 per cent. in 1946, 76 per cent. to 65 per cent. in 1947. The general forecast for light yields in 1948-49 was substantiated in early pickings in all districts.

The pruning trials laid down last year were harvested in autumn, and, in addition, complete bud burst records were made of the trial at the Research Station in spring.

The small-scale weed control trials on uncultivated areas have been continued, this year using "Hormex", a 2,4D preparation, for the first time. This has shown considerable promise against hardhead (*Centaurea picris* Pall.), which previously has not been controlled. "Hormex" also appears to be at least as effective as "Methoxone" for controlling hoary cress (*Lepidium draba* L.).

A trial was conducted on Zante currant vines to see whether a spray containing a growth-regulating substance (5 p.p.m. of 2,4D) could be used as a substitute for cincturing in aiding fruit set. Spray treatment increased the yield from both cinctured and uncinctured vines, and on a dry-weight basis there was no significant difference between vines sprayed and not cinctured and vines cinctured and not sprayed. This trial will need to be continued for several years before any definite conclusions can be drawn from it.

In another trial, also on Zante currant vines, a naphthalene acetic acid at 200 and 600 p.p.m. was used as a spray in autumn in an endeavour to delay bud burst in the following spring. The treated vines were defoliated sooner than the untreated, but there was no difference in time of bud burst.

Observations and measurements on the growth of citrus shoots were continued.

Early work at the station indicated that the chlorine content of vine leaves has a diagnostic value in regard to the sodium chloride status of the soils and to vine health and increases with the age of the leaf. The leaf examinations have now been extended to cover variations of chloride with the age and position of the leaf and with chloride of the soil in which the vines are established.

Monthly determinations over thirteen months of the chloride content of leaf samples from ten orange trees failed to provide evidence of a definite increase in chloride content with increasing age of the leaf.

The incidence of frost damage in vineyards has been further examined and cultural operations in vineyards of the dried fruit area are modified in accordance with their effect on the severity of the frost. The major modifications are the destruction of cover crops prior to vine growth, avoidance of cultivation, and irrigation as far as practicable with the roster system prior to the period of maximum frost danger. The frost fan installed in a Merbein vineyard was operated during the spring months, but no frost sufficiently severe to cause damage was experienced; this work is now being concentrated in the Murrumbidgee Irrigation Area.

(*d*) *Plant Nutrients.*—Results of fertilizer trials showed the usual yield increases due to sulphate of ammonia except at Woorinen, where soil alteration associated with fertilizer applications has been noted. The application of sulphate of ammonia in more than one dosage during the growing season showed in the first season no difference in comparison with a single dressing in early spring. Potash as usual gave no yield increases and no observable improvement in quality when applied to sandy soils producing grapes of low quality and prone to wastage.

A field fertilizer trial on citrus, including the use of compost and of the raw material (waste from dried grapes) similar to that included in the compost, was discontinued after two years. The raw waste material had a deleterious effect on the growth of orange trees, which exhibited poor and delayed growth and poor fruit setting, in contrast to other treatments in the same orchard.

It has previously been reported that tomato plants irrigated at periods of three weeks gave better results than those irrigated more frequently. In order to determine whether nitrate leaching contributed to this result, the soil nitrate was ascertained weekly in plots under 1, 3, 4, and 5 weeks' irrigation periodicity. No nitrate differences associated with irrigation were detected but the results showed some evidence of a 25-day cycle of nitrate production.

Minor element deficiency trials have been continued on the Zante currant and the Gordo blanco. All pruning cuts were swabbed immediately after pruning with a concentrated solution of a salt containing boron, copper, iron, manganese, molybdenum, or zinc. Applications of copper sulphate caused injury to the vines in one instance, and applications of other minor elements have had no noticeable effect. Zinc swabbing trials, on a small survey basis applying 20 per cent. zinc sulphate to the pruning cuts, were continued, utilizing the same plots of Gordo vines as in the previous season. Of nine plots harvested, two gave a large increase, one of which was particularly striking because the treated vines outyielded the untreated by 75 per cent. On the other seven plots, yields from swabbed and unswabbed plots were approximately the same.

Investigations are in progress on the boron content of vine and citrus leaves grown on the main soil types in the district. High boron figures associated with toxicity symptoms and leaf fall have been recorded in citrus. Samples of sultana vine leaves were collected from several hundred sites throughout the settlements and the boron content determined colorimetrically. The mean value of boron content of sultana leaves was of the order of 150 parts per million, with the highest values about 1,000 p.p.m. It is not yet known whether amounts of this order are affecting the health of the vines.

A similar survey is being commenced for zinc content.

Iron chlorosis investigations have been continued. An attempt is being made to correlate sap composition and soil conditions. The beneficial effect of lucerne on chlorotic fruit trees when grown as a permanent cover crop has been further demonstrated, and the effect of such cover crops on soil conditions is being studied. It has been shown that lucerne has had little effect on the pH of the air-dried soil, and its effect on pH of soil *in situ* is being investigated.

(*e*) *Vine Pests and Diseases.*—Two vine diseases—*Gloeosporium amphelophagum* (black spot) and *Oidium tuckeri*—appeared in the vineyards in the spring, and were successfully controlled by standard treatment.

Entomological pests of significance during the year include the grape vine moth (*Phalaenoides glycine*), the light brown apple moth (*Tortrix postvittana*), and the vine leaf blister mite (*Eriophyes vitis*). The larvae of the grape moth were less in evidence. The light brown apple moth caused concern in individual vineyards.

Unseasonable rains in February before sultana harvesting were exceptionally prolonged, causing widespread damage to the grapes. Moulds and ferments followed, and rot and ferment were associated with large-scale development of the vinegar or ferment fly (*Drosophila* sp.).

(*f*) *Vine Fruit Processing.*—This work is reported in detail in Chapter XI., Section 12. Projects in hand are outlined below.

Further work was carried out on substitutes for the usual vegetable oil emulsions.

The effect of potash strength in the cold dip on the drying rate of sultanas was reinvestigated under the very adverse drying conditions prevailing.

Investigations were made of heated bulk dips and it was shown that bulk handling methods are practicable with a modified hot dip.

Work was undertaken on the caustic soda dip heated to 200° F. and on the use of potassium propionate in hot and cold dips.

Work has continued on sulphite temperature dips containing potassium or sodium sulphite and caustic soda instead of the usual potassium carbonate and caustic soda.

Investigations have been made on the sulphuring of sultanas in a sulphur chamber with the fumes of burning sulphur before dipping, and on mould control with sulphur during unfavorable weather while fruit is drying on the racks. Colour changes during sulphuring have also been examined.

The oil emulsion detergent washing treatment has proved useful in salvaging badly damaged sultanas.

The use of "N.D.G.A." as an antioxidant in retarding the development of rancidity in peanut oil has been satisfactory in commercial practice.

(*g*) *Vegetables.*—Vegetable investigations were continued during the 1948-49 season, in co-operation with officers of the Division of Plant Industry, in Red Cliffs (Victoria) and Buronga (New South Wales). The work was confined to glasshouse and field-grown tomatoes, irrigation of tomato plants, soil fumigation with DD for control of rootknot nematode in tomatoes, and field trials of soybeans and guar grown under irrigation.

With tomatoes, investigations were continued to determine the most suitable varieties for the district and to develop *Fusarium*-wilt-resistant hybrids with desirable agronomic characteristics. Results of the trials have indicated that Pearson 29-17 is one of the most suitable varieties for mid-Murray Valley conditions, and that no *Fusarium*-wilt-resistant hybrid has yet been developed which has all the desirable agronomic characteristics and is suitable for the Mildura district.

Investigations on the periodicity of irrigation for tomato plants grown on a sandy soil (Barmera sand) were carried out. From these results and those obtained in previous trials, it would appear that tomato plants grown on a Barmera sand soil type need not receive water until the amount of evaporation from the time of the previous watering has reached between six and eight inches, or approximately three to four weeks of normal summer weather.

Root-knot nematode or eelworm (*Heterodera marioni*), which thrives in light sandy soils, has become a serious pest in the Mildura district both in field and glasshouse tomatoes. A trial was carried out at Red Cliffs (Victoria) to investigate the effectiveness of control by soil fumigation with DD (an approximately equal mixture of 1, 3 dichloropropene and 1, 2 dichloropropane) at a standard application rate of 200 lb. per acre when applied to the soil at a depth of 7-8 inches at 12-inch spacings, and the effect of introducing the organism into a clean area on seedlings that had been raised in infected soil. Results disclosed that effective control was obtained by soil fumigation with DD and that there is a very great danger of introducing the disease into clean areas on the roots of seedlings raised in infected soil.

Trials were continued to investigate the possibility of growing and developing a more suitable variety of glasshouse tomato than the one commonly grown in the district, namely, South Australian Dwarf. Seventeen varieties and hybrids were included in the trial.

Replicated field trials of soybeans and guar under irrigated conditions were again carried out. The most productive of the eight varieties of soybean tried was Hawkeye, which yielded the equivalent of 32.5 bushels per acre. Richland, the next most productive variety, yielded 17.2 bushels per acre.

Vitamin C determinations were carried out on the tomatoes grown in the variety trial at the Red Cliffs vegetable plot. All varieties showed an ascorbic acid content of 24-30 mg/100 g.

The trial using the three different methods of preparing the sample, viz. (*a*) expression of juice, (*b*) grinding the sample with acid washed sand, and (*c*) dispersion with a Waring Blendor, was continued, repeating the estimations with variety Pearson 29-17 and also employing a hybrid variety.

There was again a highly significant difference between (*a*) and (*b*), and (*a*) and (*c*), but the difference between (*b*) and (*c*) was not significant for Pearson 29-17 in 1949, and significant only at the 5 per cent. level for the hybrid.

3. IRRIGATION RESEARCH STATION (MURRUMBIDGEE IRRIGATION AREAS) GRIFFITH, NEW SOUTH WALES.

Work at Griffith has been concentrated mainly on physiological and chemical studies of plants under irrigation when subjected to various manurial and management practices; a study of the physical properties of soils under irrigation; and a detailed study of tree development and yields of oranges under various cultural, irrigation, and fertilizer practices.

As indicated in the previous year's report, the extension service formerly associated with the Station has been transferred to the New South Wales State Department of Agriculture. The Organization is co-operating in the work of the service and has seconded officers working in it to the Department.

(*a*) *Irrigation.*—Water movement from furrows has been examined and the result shows some important relationships to furrow shape and size in the rate at which water enters the soil. It has been possible to show to what extent this rate of absorption obeys or departs from the formula in general use. Comparisons have also been made with the "Spot" infiltration test commonly used in studying water movement into soils.

The nature of the lateral movement of the wetted front from furrows, or "soakage" as it is commonly called, has been examined and a formula established. In general this movement is independent of furrow shape or size.

In cases where the lateral soakage is important, as in watering up to a row of seeds or seedlings, tests have shown that the greatest economy in the use of water can be obtained by a slight reduction of spacing of rows. By making a 20 per cent. reduction in spacing, a 50 per cent. saving in water to irrigate the rows can be effected.

Tests have also shown that for any given row spacing the moderate or average sized furrow commonly used wastes the greatest quantity of water. Economy can be effected by using either large furrows well filled or else very small furrows where the rate of water absorption is severely restricted.

(*b*) *Chemical Investigations.*—The work on leaf chloride as an index of salting has been carried a stage further and it has been possible to set approximate threshold values to the incidence of tree injury and reduction in yield of citrus. The major interfering factor in this objective is the simultaneous presence of sulphate salts. Although chlorides generally predominate in M.I.A. soils, in many cases the soil salts contain a substantial proportion of sulphates. Investigation of this aspect of the problem therefore becomes necessary.

The analysis of plant material for total sulphur content has been investigated in order to deal with the metabolism of sulphur which occurs when sulphate salts are taken up by the plant. After adopting the standard magnesium nitrate ashing method of the Association of Official Agricultural Chemists it was found that this method is not completely reliable and may return only about 80 per cent. of the true value. Previous comparisons between total sulphur and (water-soluble) sulphate sulphur show that sulphates in certain salted plant material comprise between 26 and 60 per cent. of the total sulphur. Consequently the water-soluble sulphur cannot be used an an index of the level of sulphate salting. It is now proposed to use the more reliable though slower combustion method for determining total sulphur. Progress on visual methods of diagnosing salt injury has been slow. Certain leaf symptoms associated with salting have been found to be affected by seasonal conditions; often the occurrence of a particular symptom is altered by a defoliation which is selective for that symptom. It has not been possible to induce the symptom known as "tip-burn" by the application of sodium chloride to the soil around citrus trees.

Work in conjunction with the Water Conservation and Irrigation Commission on the drainage of land by pumping away the water accumulated in underlying sandbeds has now been concluded.

(*c*) *Drainage.*—Drainability studies to determine the best depths and spacings for tile drains have been extended to cover more soil types. Principles are being clarified and it is now possible to reduce the size of the experimental area without invalidating the results. These results have been applied in a farm-size tile drainage trial. The efficiency of the tile drainage system is being determined by recording change in tree health and yields, and also in the salinity of the soil and drainage effluent. Some measure of improvement is evident after one season's drainage.

The use of mole drainage is being investigated.

The possibility of using salted horticultural land for dairying has been investigated, and the principles governing the establishment and management of fodder crops under these conditions are being worked out. Results to date emphasize the necessity for precise grading of the land and for irrigation facilities appropriate to the soil types concerned.

(*d*) *Horticulture.*—A factorial field experiment involving cultural, irrigation, fertilizer, and stock and scion treatments was planted in 1941. The different treatments were begun during the winter and spring and had immediate effects on the soil and the growth and yield of the trees. Where no cultivation is practised and the weeds are mown the trees suffer acute nitrogen deficiency even when 4 lb. sulphate of ammonia per tree is added. The deficiency results in reduced growth and quality. The nitrogen treatments in future will range from 0 to 16 lb. sulphate of ammonia per tree. Where cultivation is eliminated and the weeds are controlled by oil spray the yield the first year is increased about 20 per cent. over the cultivated plots. These results are interesting and are being followed up to try to ascertain the cause. Studies on quality and leaf nitrate have been initiated.

A survey of the root distribution of orange trees has shown that the root system of trees on light soils tends to be more extensive and deeper than those on heavier soils.

Trials have been begun to test the value of 2,4D in controlling pre-harvest drop in navel oranges and grapefruit. Pilot trials last season (1947) gave promising results.

Trials are being continued with vertical axis fans for the control of frost damage in orchards. Trials in the winter and spring of 1949 were promising and showed that a fan with 7 horse-power capacity could raise the temperature 2° over an area of about one acre in citrus and about two acres in almonds. These trials are conducted in co-operation with the Section of Meteorological Physics.

(*e*) *Vegetables.*—Studies on the degree of "fixation" and rate of accumulation of phosphatic fertilizer have been continued. In a field experiment with tomatoes and cabbages a 6 cwt. per acre dressing of superphosphate in the previous year was found to be only half as effective as a similar dressing in the current year. A dressing of superphosphate two years before was of similar value to an equivalent dressing in the year prior to the crop. Other trials show an additive effect of annual dressings which may quickly accumulate such a reserve of available phosphorus in the soil that no further benefit is derived from additional dressings of phosphatic fertilizer.

Further information was sought on the value of spring fallows of various lengths in the decomposition of crop residues and the subsequent accumulation of nitrates in the soil. A fallow period of one month and of two months following a wheat crop was compared with no fallow in respect to response to added nitrogen. All three treatments responded to added nitrogen, the optimum amount required (as reflected in the yield of tomatoes) being about 1 cwt. per acre of sulphate of ammonia. However, the increases due to unit amounts of additional nitrogen on the two-months fallow area were significantly less than on the one-month and no fallow areas.

Equipment is being assembled to test the possibilities of anhydrous (gaseous) ammonia, a nitrogenous fertilizer new to Australia. This form of nitrogen has many advantages over conventional fertilizers, particularly in irrigation areas where it can be applied dissolved in the irrigation water. Its use will be investigated for both fruit and field crops.

(*f*) *Plant Physiology.*—The study of methods for the accurate measurement of plant growth has progressed to an advanced stage. Results have been prepared for publication. With field-grown tomatoes, the procedure adopted gives a twentyfold increase in precision over that obtainable with simple random sampling. Moreover, the relative benefits are greater, the greater the variation in size of the experimental plants.

The sampling procedure is being applied to a study of the problem of soil fertility as affected by organic manuring. Most of the work is being done with rice hulls. To learn the causes of the useful effects of rice hulls on plant growth a glasshouse experiment was done to test the fractions, cracked grain, hulls, and bran using nitrogen and phosphorus as nutrients. The results are being analysed.

With our warm climate, the growth of plants and consequent yield of crops largely depend on soil moisture. As we can control this important plant growth factor by irrigation, it is important to understand how plants respond to difference in soil moisture.

Plant-water relationships are being investigated by established methods of plant growth analysis. Experiments have been conducted to assess the effects of a moderate and a severe wilt on the growth of young tomato plants at approximately the eight-leaf stage, considered from the standpoints of the plant as a whole and of its parts. Severe wilt treatment consisted of reducing soil moisture to the permanent wilting percentage, whereas moderate wilt treatment was a condition of obvious water stress within the plant occurring when soil moisture was well above the permanent wilting percentage, and repeated during the period of severe wilt treatment.

In the first experiment of this nature, wilting caused the expected check to growth, but upon returning to normal soil moisture levels, relative growth rates tended to be greater in wilted than in control plants. Analyses for total nitrogen of all plant parts have been completed and analyses for protein nitrogen and phosphorus are in hand. The dry-weight changes of individual laminae and petioles have suggested that the earlier and later formed leaves behave differently in response to treatment. Accordingly, improved accuracy is being sought by a consideration of leaf weights in relation to their areas at an earlier date. Also, a larger experiment of a similar nature has been conducted, concentrating on characteristics of leaves 2 and 6 as representatives of earlier and later formed leaves. The experiments have been conducted in the glasshouse. A method for obtaining root systems freed from soil has been developed.

V. ANIMAL HEALTH AND PRODUCTION.

1. General.

Research into problems of animal health and animal production has formed an important phase of the Organization's activities. This work is undertaken within the Division of Animal Health and Production, with head-quarters in Melbourne, Victoria.

The major activities of the Division have been concerned with problems of interest to the sheep and cattle industries, and this work is described in detail in Chapter VII., Sections 5-7, 9 and 12-19, and Chapter VIII. The remainder of the present chapter outlines the various projects in hand within the laboratories and field stations of the Division.

Division of Animal Health and Production.—During the year progress with new investigations continued to be very difficult on account of the shortage of trained personnel and of essential materials.

As in the past, some of the work reported is being carried out in co-operation with other Divisions and some with Departments of Agriculture and Universities in the several States.

2. Animal Health Research Laboratory, Melbourne.

(*a*) *Pleuropneumonia of Cattle.*—Work on vaccines has continued (*see* Chapter VIII., Section 2 (*a*))

(*b*) *Tuberculosis of Cattle.*—Further progress has been made in the study of the detection of tuberculous animals not reacting to routine intradermal tuberculin tests (*see* Chapter VIII., Section 2 (*b*)).

(*c*) *Mastitis in Dairy Cattle.*—Trials of newer preparations of penicillin were made and an experiment conducted on the control of the spread of *Str. agalactiae* (*see* Chapter VIII., Section 2 (*c*)).

(*d*) *Haematuria vesicalis.*—Examination of compounds in urine of cattle has continued (*see* Chapter VIII., Section 2 (*e*)).

(*e*) *Anaplasma centrale.*—The strain of *A. centrale* has been further propagated in calves.

(*f*) *Effect of Long-continued Cutaneous Applications of DDT Oily Solutions to Cattle.*—This experiment is being concluded by slaughter of the animals concerned (*see* Chapter VIII., Section 4 (*f*)).

(*g*) *Brucellosis in Cattle.*—An experiment was begun to determine whether intracaudal vaccination is as effective as standard vaccination in protecting cattle against infection and abortion (*see* Chapter VIII., Section 2 (*d*)).

(*h*) *Bacterial Oxidation of Arsenical Cattle-dipping Fluids.*—The study of the enzymic mechanism of arsenite oxidation by the pseudomonads isolated from "oxidized" dipping fluids has been continued (*see* Chapter VIII, Section 4 (*e*)).

(*i*) *Caseous Lymphadenitis of Sheep.*—The experiments on the protective value of animal vaccination one month before the sheep are shorn have been continued (*see* Chapter VII., Section 15 (*a*)).

(*j*) *Toxaemic Jaundice of Sheep.*—The investigations have been continued with the active support of the staff of the Veterinary Research Station, Glenfield, New South Wales. Those centred at the Field Station, Barooga, New South Wales, were designed for the more intensive study of heliotrope poisoning.

During the year a study of the effect of sheep grazing a pasture dominated by subterranean clover on the copper status of the animals was carried out on a property in the Adelaide Hills District, South Australia. Further work has also been undertaken on clover pastures and on molybdenum supplements. This work is described in detail in Chapter VII., Section 15 (*b*).

(*k*) *Toxicity of Wheat for Stock.*—The toxic dose of wheat for Merino sheep under laboratory conditions has been determined and the effects of the high wheat ration examined (*see* Chapter VII., Section 7).

(*l*) *Physiology of Reproduction in Sheep.*—Work has been undertaken on cyclical activity in the reproductive tract of the mature non-pregnant ewe, seasonal variation in fertility, and the development of reproductive activity in young ewes (*see* Chapter VII., Section 12 (*c*)–(*e*)).

3. McMaster Animal Health Laboratory, Sydney.

(*a*) *Parasitological Investigations—Internal Parasites.*—Studies have continued on anthelmintics, including phenothiazine and hexachlorethane, and on resistance to nematode infestations, including serological studies on resistance and immunity (*see* Chapter VII., Section 16 (*a*)–(*c*)).

(*b*) *External Parasites of Sheep.*—Work on bionomics of the body louse of sheep (*Damalinia ovis*) and the foot louse of sheep (*Linognathus pedalis*) was terminated early in the year and the results prepared for publication. Work has continued on the control of ectoparasites of sheep (*see* Chapter VII., Section 17).

(*c*) *Blowfly Strike Problem.*—Insectary trials were conducted at Canberra, in conjunction with the Division of Entomology, concerning applications of insecticides to the fleece for the prevention of body strike (*see* Chapter VII., Section 18 (*a*)).

(*d*) *Parasite Physiology and Toxicology.*—(i) *Biochemical Character of the Serologically Active Lipid Fraction of H. contortus.*—Protein, polysaccharide, and lipid fractions were prepared but only the lipid appeared to be essentially concerned in reactions with natural antisera from sheep. This lipid is hydrophilic, acid, susceptible to oxidation, free from protein and polysaccaride and has a molecular weight greater than 1,000. Similar serologically-active lipids were obtained from several different helminths but not from other organisms. The lipid of *H. contortus*, therefore, may belong to a chemically distinct class of lipoidal substances peculiar to helminths.

(ii) *Mode of Action of Phenothiazine as an Anthelmintic.*—To study phenothiazine and its derivatives in worm and host tissues, radio active S^{35} was used in synthesized phenothiazine to permit counts of radio activity with the Geiger Müller counter. The uptake of phenothiazine by nematode parasites *in vitro* was found to be about 125μg./g. dry wt./hour for *Ascaridia galli*, 180μg. for *Nippostrongylus muris*, and 270μg. for *H. contortus*. Thus, the rate of uptake of the drug was not proportional to the surface area of the parasite. *H. contortus*, the most susceptible of these parasites, took up phenothiazine at the greatest rate. Ligaturing *Ascaridia galli* at head and tail did not reduce uptake, suggesting that absorption took place largely through the cuticle. Dissection experiments showed that it was not merely absorbed on the cuticular surface. Uptake was not much affected by changes in pH of the medium but was increased in the presence of wetting agents. Drug uptake of *A. galli* and *N. muris in vivo* could be determined satisfactorily if the dose of phenothiazine used gave Geiger Müller counts of 5,000,000 and 2,000,000 per minute respectively. *A. galli* took up phenothiazine over ten times more rapidly *in vivo* than *in vitro*, the distribution of the drug within the parasite being similar in either case. The parasite *N. muris*, which is not susceptible to phenothiazine, was found to take up the drug and retain it in a similar manner to *A. galli*. Preliminary experiments suggest that parasites take up phenothiazine at a faster rate than their hosts.

(iii) *Intermediary Metabolism of Nematode Parasites.*—These studies have been continued, using *Nematodirus* spp. from sheep, *Ascaridia galli* from chickens, and *Neoaplectana glaseri* grown in artificial culture. Results obtained from homogeneous brei from these worms show that a modified form of Krebs's tricarboxylic acid cycle occurs in nematodes; acetate is used as a source of energy and coenzyme A appears to be associated with acetate metabolism, though the actual route is not yet clear. This work is showing many differences between the metabolic routes in nematode parasites compared with their mammalian hosts and it is hoped that the information derived from it can later be exploited for anthelmintic purposes.

(iv) *The Relative Importance of Aerobic Metabolism in Small Nematodes of the Alimentary Tract.*—This work has now been completed. It has shown appreciable oxygen tensions close to the mucosa of the intestine in both rats and sheep and that *N. muris*, *Nematodirus* spp., and *H. contortus* are able to utilize oxygen for respiratory purposes, even at low tensions present in the host's gut.

(v) *The Biological Significance of Haemoglobin in Nematode Parasites.*—Haemoglobins obtained in pure form from *N. muris*, *Nematodirus* spp., and *H. contortus* all showed much higher affinity for oxygen and lower affinity for carbon monoxide than haemoglobins from mammalian hosts, although spectroscopically they did not differ markedly from them. From these studies it was concluded that although capable of it, these haemoglobins are not actively concerned in transport of oxygen within the parasites when the partial pressure of oxygen in the medium is above 5 mm. of mercury. Oxygen tensions near the mucosa of the small intestine in rats and sheep vary somewhat but are approximately of this order.

(*e*) *Nutritional and Biochemical Studies.*—Field trials were conducted during the winter months of 1948 at Frodsley and Cressy in Tasmania and at the McMaster Field Station near Liverpool, New South Wales, on vitamin D supplements for sheep. Drought feeding experiments are in progress in collaboration with the New South Wales Department of Agriculture at the Glenfield Veterinary Research Station. Work on these projects is described in Chapter VII., Sections 6 and 9.

Studies are being made on seasonal changes in body weight from weaning to maturity and on problems of stall-feeding beef cattle for "topping off" purposes (*see* Chapter VIII., Section 7).

(*f*) *Physiology of Reproduction.*—(i) *Inactivation of Gonadotrophins.*—Aqueous potassium periodate at concentrations of M/5,000—M/10,000 almost completely inactivated three preparations of serum gonadotrophin. Increasing the concentration of KIO_4 did not result in further inactivation. No inactivation occurred if the KIO_4 was previously reduced with glucose. In the three preparations tested, loss of activity after periodate treatment ranged from about 93–96 per cent. and, for the most part, occurred within a few minutes. Injection of serum gonadotrophins, after their treatment with periodate, caused a greater degree of luteinization of the membrana granulosa than did untreated gonadotrophins. This was observed in both normal and hypophysectomized animals. The treated gonadotrophin differed from other highly luteinizing preparations in causing increased ovarian weight in hypophysectomized rats. Moreover, the response was not affected by subdivision of the dose. It differed from untreated gonadotrophins in being unaffected by the influenza virus. The results indicate that the effect of the periodate is to alter the hormone rather than to destroy it. This work is proceeding.

(ii) *Studies on the Mechanisms of Fertilization.*—Investigations have commenced on rabbit, rat, and mouse sperms *in vitro* as regards the effect on their mobility and longevity of the composition and temperature of the surrounding medium. The principal objectives of this work are the development of a method for preserving fertility of spermatozoa for relatively long periods at room temperature, and the fertilization of the ovum *in vitro*.

(*g*) *Other Investigations.*—(i) *Sheath Rot.*—Some further work on sheath rot has been carried out (*see* Chapter VII., Section 15 (*c*)).

(ii) *Pregnancy Toxaemia.*—Studies on metabolism of sheep are providing basic information of particular value in this connexion (*see* Chapter VII., Section 15 (*d*)).

4. VETERINARY PARASITOLOGY LABORATORY, QUEENSLAND.

This laboratory was established as from 1st July, 1948, at Yeerongpilly, Queensland, in buildings leased from the Queensland Department of Agriculture and Stock. The centre is under the administration of the Division of Animal Health and Production and accommodation is provided for officers of the Division of Entomology who are working in the field of veterinary parasitology, and who form part of the general research team on the problems under investigation.

The work of the laboratory has been devoted to studies of cattle parasites. These have included studies on *Onchocerca gibsoni* (beef nodule worm), the epidemiology of parasitic "gastro-enteritis" of calves, and helminth infestations of adult cattle, including fluke diseases of cattle. Further details are given in Chapter VIII., Section 3.

5. F. D. McMASTER FIELD STATION, BADGERY'S CREEK, NEW SOUTH WALES.

Approximately 21 inches of rain were recorded at the Station during the year ended 30th June, 1949, 12.7 inches of which fell during the summer. On account of the low and unreliable winter rainfall, oat crops have been largely discontinued. In the year under review 30 acres of sorghum, 7 acres of millet, and 15 acres of oats were grown. Approximately 150 tons of sorghum were harvested for pit ensilage. The millet was grazed by the dairy cattle. Twelve acres of Rhodes grass were planted, making a total area of approximately 110 acres sown to this grass on the Field Station. A further 10 acres of *Phalaris tuberosa* and subterranean clover were sown, making a total of 35 acres under this improved pasture.

Sheep numbers are being reduced to bring the total number within the range 600–700, which is now considered the optimal number for the property. As at 30th June, there were 63 rams, 87 wethers, and 520 ewes. Lambs reared during 1948-49 numbered 1,184. Cattle numbers have increased to 59 head.

The work of the station has been devoted largely to breeding studies on sheep, including studies of inbred flocks of merinos, an investigation of heterosis, the inheritance of component characteristics of fleece weight, and the inheritance of "hairiness". Work has continued also on fleece rot. Further details of these projects are given in Chapter VII., Sections 13 (*a*)–(*d*) and 15 (*e*).

Further work has been undertaken on the development of hybrid dairy cattle based on zebu crosses with British breeds (*see* Chapter VIII., Section 5).

6. WOOL BIOLOGY SECTION, SYDNEY.

(*a*) *Comparative Breed Studies.*—An experiment has been commenced to study sheep of Merino, Corriedale, Polwarth, and Lincoln breeds under laboratory conditions where individual animals can be fed on a uniform high-quality ration and the fleece growth accurately measured (*see* Chapter VII., Section 14 (*a*)).

(*b*) *Classification of the Hair Follicle Group.*—Investigations are being carried out to determine whether the arrangement and activity of wool follicles within the skin will provide a means of measuring heritable variations in the external fleece (*see* Chapter VII., Section 14(*b*), (*c*), and (*e*)).

(*c*) *Study of the Progeny of Three Top Sires in an Australian Merino Stud.*—A study has been made of the ewe progeny of three outstanding sires in an important Australian Merino Stud (*see* Chapter VII., Section 14(*d*)).

7. REGIONAL PASTORAL CENTRE AND LABORATORY, ARMIDALE, NEW SOUTH WALES.

As mentioned in the report for the previous year (Chapter IV.), this Regional Centre has been established for co-operative work between several Divisions of the Organization and the Department of Agriculture of New South Wales. During the past year development has continued. Owing to building difficulties laboratory accommodation is still restricted, but rather more progress was made in the development of the Chiswick Field Station and it has been possible to commence some of the experimental projects. The following projects have been undertaken by the Division of Animal Health and Production at Armidale during the year.

(*a*) *Blowfly Strike in Sheep.*—Work has been undertaken on dressings for the prevention of fly-strike in wounds following lamb-marking, and on the prevention of body strike in sheep (*see* Chapter VII., Section 18 (*a*) and (*b*)).

(*b*) *Internal Parasites in Sheep.*—Studies have continued on the correlation between variations in climatic conditions and changes in the worm burden and on the winter feeding of weaners in relation to worm infestation (*see* Chapter VII., Section 16(*e*) and (*f*)).

(*c*) *Neo-natal Mortality in Lambs.*—Following the preliminary observations reported last year a systematic investigation of this problem has been undertaken (*see* Chapter VII., Section 19(*a*)).

8. NATIONAL FIELD STATION, "GILRUTH PLAINS", QUEENSLAND.

Rainfall for the year ending June, 1949, was 20.44 inches. The first five months were dry, and dust storms damaged much of the standing dry feed. From December on, seasonal and pasture conditions improved rapidly.

Lambing percentages were very high, 107 per cent. being recorded in one flock. Lamb-marking was postponed until mid-January when, although losses had been serious, 80 per cent. of lambs were marked from 3,500 ewes. At 30th June there were 4,878 sheep on the property, comprising 3,619 ewes, 857 rams, and 382 wethers. During the year, 150 head of beef cattle were purchased to keep the pastures in order for the sheep.

A total of 8,760 sheep were shorn for an out-turn of 222 bales. The wool cut per head of the two-tooth ewes was 10 lb. 6 oz., and for rams of similar age 12 lb. 11 oz.; for aged ewes the figure was 9 lb. 7 oz., and for lambs 3 lb. 1 oz.

During the humid autumn weather, blowfly strike was severe in lambs prior to treatment with the modified Mules operation, and on rams' heads. Some polled Merino rams under observation showed complete freedom from strike throughout this period. During autumn, also, an outbreak of "pink-eye" occurred, but was not so serious as in 1948. Generally the health of the flock throughout the year was good.

Investigation of methods of breeding continued to form the main animal experimental work at the Station. The technique of mating and lambing the experimental groups in special yards again gave very satisfactory results.

The main breeding trial, which aims at contrasting three systems of animal breeding, has continued, as has work on heterosis. The Station also provides one of the environments under which the performance of selected strains of Merino sheep are being studied (*see* Chapter VII., Section 13(*e*) and (*f*)).

9. OTHER INVESTIGATIONS.

(*a*) *Fleece Analysis Laboratory, Villawood, New South Wales.*—This laboratory has continued to perform the measurement of the characteristics of fleece samples submitted by the various Divisions of the Organization. During the year some 23,000 measurements were made, covering scouring tests, fibre diameter, fleece density, crimp and staple length.

An automatic fibre-length analyser has been developed to the point where it can be used reliably (*see* Chapter VII., Section 19(*b*)).

(*b*) *Investigation of Beef Production in Australia.*—The survey of beef-production in Australia has continued (*see* Chapter VIII., Section 6).

(*c*) *Poultry Breeding Investigations, Werribee, Victoria.*—The poultry breeding research unit at the Organization's field station at Werribee, Victoria, has been satisfactorily established. The main project, a comparison of breeding systems, has proceeded according to plan and fourteen separate breeding flocks have been established, totalling in all about 3,000 birds. These are housed together under uniform conditions. Artificial insemination, as the standard method of mating at the centre, has continued to give satisfactory results, and the experience gained with this technique has opened a wide field of investigation. It has shown that the aging of semen, even for such a short period as a few hours, considerably lowers its fertilizing capacity. Three methods of obtaining individual egg records have been tried out—trap-nesting, single bird pen, and single bird battery cage. Of these, the laying battery has given the best results and 1,000 birds are now being kept under this system.

VI. NUTRITION.

1. GENERAL.

The Organization's work on nutritional problems has been largely confined to studies of the nutritional physiology of the sheep and the influence of nutrition on wool production. This work has been undertaken within the Division of Biochemistry and General Nutrition, which has head-quarters and laboratories situated within the grounds of the University of Adelaide.

The major activity of the Division has been concerned with the sheep. This work is described in detail in Chapter VII., Sections 2-4, 8, 10 and 11. The remainder of the present chapter outlines the projects in hand within the Division.

Application of its findings to the practical problems of the sheep industry is obviously returning economic dividends. A striking example is the recent demonstration that huge tracts of terrain in southern Australia hitherto abandoned as useless for agriculture are limited by deficiencies of zinc and of copper within the soils, and that these limitations may be simply and effectively overcome by applying manurial dressings containing these elements. The results of these experiments have indicated the way for the developments of great economic significance which are now proceeding. These are spectacular results and are generally recognized, but the knowledge obtained from many other researches is finding its way more subtly into practice and is of similar importance in rendering industry more productive and more efficient.

Division of Biochemistry and General Nutrition.—The new laboratory building in the grounds of the University of Adelaide immediately adjacent to the present Nutrition Laboratory and its annexes is now practically complete. The Chief of the Division and his colleagues are grateful for the extra accommodation and magnificent facilities that this modern laboratory will provide, which will add greatly to the convenience and the efficiency of the work. For a considerable period a wide programme of active research has been carried out under difficult conditions.

Further improvements have been made to the Division's main field station at Glenthorne, which is situated about 11 miles from the laboratories, but it is clear that several years may elapse before this station is developed into a completely efficient tool for research. The work there is limited by the fact that materials for fencing, &c., are not yet available. Nevertheless, valuable experiments are being carried out at this site.

During the year the Chief of the Division was elected a Fellow of the Royal Society. He visited the United Kingdom during November, 1948, at the invitation of the Royal Society to deliver a lecture on the work of the Division on the role of trace elements in animal nutrition.

The close co-operation between the Division and the University of Adelaide, which, since the inception of the work, has done so much to foster the spirit of research, has continued. A similar close liaison with the officers of the South Australian Department of Agriculture and with other colleagues whose duties and interests lead to similar ends has ensured rapid and efficient application of research findings to the pastoral industry.

2. Nutrition and Wool Production.

Study of the relationship between nutrition and wool production has been continued with further investigation of the utilization of protein. The physiological mechanisms that so seriously limit the efficiency of the conversion of amino acids to wool keratin have been revealed and the extent of their influence measured under different nutritional conditions. These studies have demonstrated unequivocally that the rate of wool growth is determined by a number of interactions which vary independently with the state of the energy balance of the animal. This work is reported in detail in Chapter VII., Section 2.

3. Metabolic Studies.

Previous reports have discussed the nutritional importance of the simple fatty acids which, as products of the microbiotic dissimilation of carbohydrates in the paunch, constitute the main source of energy for ruminants. The considerable difference between the capacity of acetic and propionic acids to provide energy to the living processes which has been demonstrated here by calorimetry experiments with sheep is of great fundamental importance in the field of energy metabolism. Although both acids are oxidized completely, propionic acid yields much more effectively its combustible energy to the living processes.

Studies of the fermentation of carbohydrates by the symbiotic flora in the rumen, and of the intermediary metabolism of the products, have been extended and are rapidly filling in the pattern of knowledge of the nutrition of the sheep.

This work, which is concerned with (*a*) the utilization of urea, (*b*) the fermentation of carbohydrates in the rumen, (*c*) the absorption of fatty acids from the rumen, (*d*) the intermediate metabolism of fatty acids, (*e*) ketone production by the sheep, and (*f*) energy metabolism, is described in detail in Chapter VII., Sections 3 and 4.

4. Vitamin A Requirements of the Sheep.

The series of studies on the Vitamin A requirements of the sheep has been extended; they are described in detail in Chapter VII., Section 8.

5. Effects of Chronic Fluorosis in the Sheep.

The experiment to determine the effects of the chronic ingestion of small amounts of fluorine in the drinking water has now been concluded. The results are reported in Chapter VII., Section 10.

6. The Amino-acid Constitution and Chemical Structure of Wool from Copper-deficient Sheep.

Work on the lesion in the wool fleece that results from copper deficiency has continued, particular attention being given to chemical and physico-chemical analyses in an attempt to elucidate the reasons for the structural changes of the abnormal wool. Further details are given in Chapter VII., Section 11 (*c*).

7. Influence of Heavy Metals on Phosphorylation.

An investigation of the part played by copper and zinc on the phosphorylating mechanisms within plant and animal tissues has been undertaken.

8. Minor Elements in Animal Nutrition.

The study of the physiological functions that minute traces of the heavy metals assume in animals has been continued both in the laboratory and in the field. Further study has been made of the limitations imposed on the health and productivity of animals and plants by conditions within the soils which lead to deficiencies of cobalt, copper, zinc, &c.

Experiments which demonstrated the nutritional importance of copper and the effects of copper deficiency on wool production have been discussed in previous reports. Further investigation of the utilization of this element by animals has now provided a clue which will probably lead to an understanding of the paradoxical behaviour of sheep that develop the syndrome of copper deficiency while grazed on certain types of terrain where the pastures apparently contain ample copper. Experiments begun early in 1948 have shown that ingestion of moderate amounts of molybdenum may in some circumstances lead to symptoms of copper deficiency in an animal which has sufficient copper circulating in its blood stream to meet its normal requirements, and sufficient copper in its tissues for normal function. It is now apparent that the capacity of the tissues to utilize copper may be impaired by molybdenum, and, probably more effectively, by constituents other than the molybdenum in the fodder available on the affected areas.

The findings, previously reported, which have proven the nutritional importance of very minute traces of cobalt for the nutritional well-being of sheep, have recently assumed much wider significance. The essential nature of cobalt for the nutrition of all animals is now implied by the isolation of the intrinsic anti-pernicious anaemia factor from liver and by the discovery in Great Britain and in the United States of America that this essential nutrient (Vitamin B_{12}) is a relatively simple association complex of cobalt. Further studies carried out in the Division have illuminated the utilization of cobalt by animals and the physiological functions it assumes.

Details of the studies on cobalt deficiency and on copper deficiency and the influence of molybdenum on the metabolism of copper are given in Chapter VII., Section 11.

9. Plant Nutrition.

Further studies have been made of the mineral nutrition of plants in the Ninety-Mile Plain, South Australia. This work is described in detail in Chapter III., Section 22.

10. Accessory Food Factors and Food Composition.

The investigation of methods of estimation of thiamine in white bread and the application of the findings to a determination of thiamine in bread in Adelaide were completed in the first half of 1948.

The use of microbiological assay for the measurement of riboflavin has been studied and the method has been used for the determination of riboflavin in bread. The results so obtained are being compared with those given by a bio-assay. Possible complications introduced in bio-assays by microbial vitamin synthesis in the intestine of the rat are being investigated by the microbiological technique.

A preliminary experiment on the influence of the dietary protein level and vitamin intake on the occurrence of alopecia in the rat was carried out.

11. Radio-Active Isotopes.

Acetic and propionic acids in which the carboxyl groups are tagged with C^{14} have been synthesized for use in metabolic investigations and methods have been established for the estimation of the radio-active isotope of carbon in tissue, fluids, &c. The necessary instruments have been assembled for these investigations.

Investigations of the absorption and utilization of cobalt have been extended with the use of Co^{60}.

12. Field Stations.

(*a*) *Glenthorne.*—Developmental work has continued at the Division's Field Station "Glenthorne", at O'Halloran's Hill. A further 60 acres has been sown with phalaris and subterranean clover. The 150 acres sown similarly in the previous year have now been established. An area of 50 acres has been contour banked as a measure for the control of soil erosion, the work on this area being carried out with the co-operation of the Soil Conservation Service of the South Australian Department of Agriculture. A field laboratory and a building to house the food processing machinery have been planned and subsidiary apparatus for the care of the experimental flocks has been installed. About 50 acres were sown to wheat to produce the hay, straw, and grain necessary for feeding experimental animals in pens. Arrangements are being made to extend the lucerne paddocks. The experiments on the effect of molybdenum on the copper status of grazing sheep that were referred to above were carried out. The block of 50 sheep pens for experimental sheep is now nearing completion.

(*b*) *Other Field Stations.*—Work on minor elements in animal nutrition has been undertaken at the Division's Field Stations at Robe, Keith, Borrika, Glenroy, and Kybybolite. Much of this work has been mentioned above; details are given in Chapter VII., Section 11 (*d*).

VII. SHEEP.

1. General.

Wool is of the utmost importance in the Australian economy. Not only does it provide our major export, but it allows the use of vast areas of marginal land which cannot be turned to good account in other ways.

With a sheep population of over 100,000,000 Australia produces about one-quarter of the world's wool and about twice as much as any other country. More than one-half of the world's production of fine wool comes from our dry inland areas. Thus, Australia has a vital interest in ensuring that wool can withstand the threatened competition from artificial fibres.

The Organization has been given responsibility for carrying out an extensive programme of scientific research on wool under the provisions of the *Wool Use Promotion Act* 1945. The Government has set aside funds earmarked for this purpose amounting to almost £500,000 per annum in a Wool Research Trust Account.

In developing its programme of research on the agricultural side, the Organization has been concerned with soil, plant, and animal aspects of the growth of wool.

Soil fertility is obviously of prime importance and outstanding results have recently been achieved in combating soil infertility arising from minor element deficiencies. On the plant side, too, special emphasis has been placed on pasture investigations and on weed control. Work of the Organization on soils, pastures, and related matters affecting the pastoral industry are described in detail in Chapters II. and III.

Work on the sheep itself has been undertaken within the Organization's Divisions of Animal Health and Production and of Biochemistry and General Nutrition (*see* Chapters V. and VI.). This work is described in the remainder of this Chapter, Sections 5-7, 9, and 12-19 relating to the work of the Division of Animal Health and Production and Sections 2-4, 8, 10, and 11 to the work of the Division of Biochemistry and General Nutrition.

The Organization's work in the field of wool textile research is dealt with in Chapter XIV.

2. Nutrition and Wool Production.

Further progress in the study of the nutritional factors which determine wool production has revealed the main physiological and biochemical mechanisms involved in wool production. A series of papers on this subject has been prepared for publication and some have already appeared. Briefly, the ultimate nutritional conditions which determine the rate of wool growth are the concentration and composition of the assemblage of amino acids which surround the wool follicles. The quota of the amino acids absorbed from the intestine which thus eventually becomes available to serve as a substrate for wool production is influenced very materially by physiological interactions that alter with the nutritional state of the sheep. The efficiency with which the animal converts the protein in its fodder to wool fleece is, at best, very low, and varies greatly (at least 300 per cent.) according to the ability of the fodder to meet the energy requirements of the animal. Thus the main variables which determine the rate of wool growth are the quantity and quality of the protein available from the ration, and the intake of other dietary constituents capable of serving as fuel to meet the energy demands. The former determine the total substrate of amino acids and its composition, and the latter that portion of the substrate which eventually becomes available for the competing protein syntheses involved in wool production, growth, pregnancy, and lactation.

Changes in the rate of wool growth brought about by alteration of the nature and quantity of the fodder consumed are accompanied by marked changes in the quality of the wool. It is clear then that quantitative criteria upon which genetical studies are based will need to be very carefully chosen with full appreciation of the changes brought about by the nutritional environment in which the experimental animals are kept. The claim that rate of wool production is related to the nitrogen intake by the law of diminishing returns is physiologically meaningless and will be misleading if applied as a criterion in progeny testing.

A rationale for pasture management is indicated from these findings. The protein content of the pasture, the availability of this protein to the animal, and the relationship this bears to other constituents capable of providing for the energy requirements of the animal, are the three main variables which determine the efficiency of protein utilization. The first two are generally appreciated in husbandry practice, the third, which is of prime importance, has been only vaguely understood and is rarely taken into account when grazing policy is determined.

3. Processes of Rumination.

(*a*) *Utilization of Urea.*—Previous reports have commented on the possibility that simple amides such as urea may, by stimulating the proliferation of micro-organisms in the rumen, provide useful amounts of protein to the sheep. The problem of ascertaining the nutritional factors involved in the synthesis of protein in this way is clearly of prime importance.

The first series of experiments designed to throw further light on this problem indicated that moderate amounts of urea are converted to protein in this way and the resulting amino acids utilized for wool production *provided it is fed together with a relatively large quantity of starch or of simple saccharides.* The efficiency of the conversion is, however, small. To assess the economic feasibility of the use of urea as a protein supplement, it is clearly essential to determine the proportion of starch that will be necessary to ensure maximum efficiency of utilization of the urea.

The second series of experiments designed to determine this relationship is now nearing completion. It is clear from these that the proportion of starch in the diet must be large if the urea is to be converted effectively: at least ten times the weight of starch to that of urea was found necessary before supplements of urea brought about any significant increase in the wool production above that of the control animals which received the same amount of starch unaccompanied by the urea. The adoption of urea as a protein substitute for the feeding of ruminants thus depends primarily on a cheap source of suitable carbohydrate.

(*b*) *Fermentation of Carbohydrates in the Rumen.*—The early investigations in this field have been referred to in previous reports.

During the latter part of 1947-48, experiments were begun in which a large inoculum of rumen fluid was used to initiate *in vitro* fermentation of wheaten hay. These experiments have continued throughout the period under review and have shown that the substrate can be fermented within 48 hours to an extent comparable with that which occurs in 24 hours within the rumen itself. In these fermentations the dissimilation of cellulose and of the hemicelluloses and the production of methane were the same as in the rumen, so it is probable that the changes which occurred *in vitro* were identical with those which normally proceed in the living animal. The products included the same fatty acids as are normally present in the rumen fluid of sheep fed on the same fodder but the proportion of propionic acid was larger and the proportion of acetic acid smaller. This is consistent with the more rapid absorption of the former from the acid rumen contents which has been discussed in previous reports. The quantities of fatty acids recovered from *in vitro* fermentations indicate that the bacterial dissimilation of carbohydrates within the rumen of the sheep can produce each day 200-300 g. of mixed fatty acids from a kilogram of wheaten hay. This implies that the equivalent of 750-1,100 kg.cal. of combustible energy per kilo of hay would become available to the animal in this form. Simple fatty acids thus provide the major source of energy for the ruminant.

In the course of these studies a procedure for the estimation of fatty acids which involves partition chromatography on "celite" columns and has none of the disadvantages of methods that utilize silica gels, was perfected. This sensitive and critical method of analysis has provided a valuable tool for the study of the intermediary metabolism of fatty acids.

(*c*) *Absorption of Fatty Acids from the Rumen.*—The fact that fatty acids are absorbed at different rates through the rumen wall has been discussed in previous reports. The investigations have been continued. The new chromatographic methods for the estimation of very small quantities of fatty acids have been applied to the determination of the fatty acids in the venous blood leaving the rumen. Experiments have shown unequivocally that propionic acid is absorbed much more rapidly than acetic acid from the contents of the rumen, but the blood draining the rumen contains a preponderance of acetic acid. Apparently, then, propionic acid is altered during its passage through the rumen wall or is drained from the rumen through the lymphatics. Further attention is being given to these aspects of the problem. A complete understanding of this phenomenon is essential for a proper appreciation of the digestive processes of ruminants.

(*d*) *Intermediary Metabolism of Fatty Acids.*—The fact that simple fatty acids constitute the main source of energy for ruminants has been mentioned previously. During the period under review a comprehensive series of experiments has been conducted to determine the course which acetic and propionic acids take in intermediary metabolism. The excretion of sugar, nitrogen, and ketone bodies in the urine was determined under different conditions in about 50 sheep that had been treated with phlorhidzin while fasting. A constant sugar : nitrogen ratio of approximately 2.8 was obtained in most cases. Acetic acid administered by intravenous ingestion or into the alimentary tract under these conditions brought about no significant change in this ratio, whereas propionic acid administered similarly increased it materially. The intermediary metabolism of acetic acid is thus distinct from that of propionic acid. Acetic acid is markedly ketogenic, whereas propionic acid is converted to sugar and is anti-ketogenic. The work is being continued.

(*e*) *Ketone Production by the Sheep.*—As part of the studies in intermediary metabolism of fatty acids, the metabolic origin of aceto-acetic acid and β-hydroxic acid in the sheep under different nutritional conditions is being investigated. A series of papers on aspects of these researches has been prepared for publication.

4. Energy Metabolism.

The study of various aspects of the energy metabolism of the sheep has continued, and for this purpose the two calorimeters and subsidiary apparatus for maintaining sheep under critically controlled conditions have been in constant use.

The relatively large amount of energy that is dissipated without performing any useful work in the animal has been proved to be directly proportional to the intake of fodder and to vary with the type of fodder. From experience with the energy transactions of other animals it is clear that this inefficiency in the utilization of the energy available from the fodder is characteristic of the ruminant. The fact that the ultimate source of energy for ruminants differs very markedly from that of other animals has been discussed previously: in the former the main fuel is provided by simple fatty acids arising from fermentation of carbohydrates in the paunch, and in the latter it is provided by simple sugars arising from the hydrolysis of starch and simple saccharides by the enzymes of the alimentary canal. The problem thus devolves on the relative capacities of sugar and the fatty acids to provide energy to the living processes. During the past year we have shown unequivocally that, *in vivo*, propionic acid provides practically the same proportion of its energy to the living processes on oxidation as sugar to which it is readily converted, but the metabolism of acetic acid is quite different and much less of the energy liberated on its oxidation is capable of fulfilling the energy demands of living tissues.

The reasons for the extraordinary differences between the energy transactions of ruminants and those of other animals are now rapidly becoming clearer.

The findings are of broad fundamental importance in nutritional physiology, and are essential for a rational approach to drought feeding.

5. Carbohydrate Metabolism.

One of the research officers of the Division of Animal Health and Production has carried out work at Cambridge during the last two years which has thrown new light on the requirements and utilization of glucose of sheep and on the role of acetate in ruminant metabolism.

6. Drought-feeding Experiments.

This work is being carried out in collaboration with the New South Wales Department of Agriculture at the Glenfield Veterinary Research Station. Construction of the unit for the drought-feeding experiments, which are supported by a grant from the Burdekin Bequest, was completed and trials commenced in November, 1948. Twelve groups, each of 24 Merino wethers, are being used to study the effect of continued feeding on rations containing different proportions of concentrate (wheat) and roughage (wheaten chaff) ranging from 50/50 to 90 concentrate/10 roughage. Some groups are fed daily and others once weekly at a proportionate rate. All these rations are supplemented with 1 per cent. finely ground limestone to correct the low Ca : P ratio of the cereal constituents. In addition, two groups of 50 Merino ewes are being fed on a low Ca : high P_2O_5 ration, with and without the addition of finely ground limestone, to determine the effect of the unbalanced ration on conception and birth rate. The work has not been in progress long enough for any definite conclusions to be drawn but it is bringing to light a number of interesting problems in relation to drought feeding which will repay closer investigation.

7. Toxicity of Large Rations of Wheat.

It was found that the toxic dose of crushed wheat for Merino sheep under laboratory conditions is 75-80 g./kg., i.e., 6 lb. for a sheep weighing 80 lb., which is a much greater amount than they will voluntarily consume. After administration of these amounts a rapid change of ruminal and bowel flora occurs, leading to its virtually complete replacement by lactobacilli, the production of large amounts of lactic acid (1 per cent. or more), and a fall of ruminal pH to about 4.2. This may be accompanied by a rise of blood lactate to over 200 mg./100 ml., a fall of blood pH to as low as 6.6 and of alkali reserve to as low as 6 vol. CO_2/100 ml. The animals die of acid intoxication, depletion of alkali reserve, and haemoconcentration. Lower dose rates of wheat lead to less severe disturbances of the acid-base equilibrium, with recovery. As under field conditions (usually during drought) there is evidence that lower consumptions than 75-80 g./kg. may lead to death, the possible reason is being sought. An interesting and possibly important finding is that the form of lactic acid produced in the bowel after wheat administration is predominantly the laevorotary d(−) enantiomorph. During the course of this work it was demonstrated for the first time that lactic acid can be absorbed into the blood stream from the reticulo-rumino-omasal field, at least under acid conditions (pH 4.2). Although direct experiments were not made with horses in the past year, the presence of very acid stomach and bowel contents (pH 4.2) and a lactobacillary type of bowel flora had been previously noted, suggesting that, in horses also, disturbances of the acid-base equilibrium by lactic acid formed in the bowel may be an important factor in the fatal illness after wheat consumption. It is interesting that in the fatal cases in horses the dose rate of wheat (voluntarily consumed) was only about one-seventh of that found necessary in sheep.

8. Vitamin A Requirements.

The series of studies on the vitamin A requirements of sheep and their significance has been referred to in previous reports. Another experiment involving 22 mature ewes was started early last year. In the course of eleven months these animals have been slowly depleted of vitamin A to the low level indicated by the very small amount of vitamin A circulating in their bloods. These have been divided into groups and the vitamin A status is being increased in some so that an ordered series of deficiency states will result. They will then be mated and the effects on reproduction observed.

9. Vitamin D Supplements.

Field trials were conducted during the winter of 1948 at Frodsley and Cressy in Tasmania and at the McMaster Field Station near Liverpool, New South Wales. At these centres, Corriedale, Merino and crossbred weaners were grazed in groups on greenfeed oats, Italian ryegrass and natural pastures, some of each group being treated with massive doses of vitamin D as "Calciferol". The response to the vitamin D supplement at the Tasmanian centres was not so spectacular as that recorded at Vaucluse, Tasmania, in 1947. At the McMaster Field Station, with poorly-developed Merino weaners grazing a pure stand of Algerian oats, there was a well-marked response to the vitamin D supplement, viz., blood calcium and phosphorus levels remained normal throughout and there was a steady increase in body weight compared with the control groups on natural pasture and on oat grazing without vitamin D supplementation. The difference between the Tasmanian results in 1947 and 1948 may have been due to the fact that seasonal conditions necessitated a later start and subterranean clover, which was present among the oat crops, became dominant when the trials had been in progress for about two months. In addition, only about one-third as much rain fell during the trial period in 1948 as in 1947. An outstanding feature of these trials was the steady increase in body weight throughout the winter (2.0-2.35 lb. per week) of weaners on greenfeed oats or Italian rye compared with those on natural pasture, whose weights remained practically stationary. Moreover, when the groups were shorn in November, those which had been on the better feed for thirteen weeks during the winter cut 30 per cent. more wool. Further trials on similar lines for the winter of 1949 have recently commenced.

These have been planned to determine whether the presence of subterranean clover was responsible for the non-effect of vitamin D supplements in Tasmania in 1948, or the effect of seasonal conditions.

10. Chronic Fluorosis.

The experiment to determine the effects of the chronic ingestion of small amounts of fluorine in the drinking water has now been concluded.

Five groups of sheep have been confined for three years to drinking water containing respectively 0, 2.5, 5, 10, and 20 parts of fluorine per million. The smaller quantities of fluorine had no untoward effects during this period on the general well-being of the animals—their body weights were not significantly affected—and there was no significant difference in wool production throughout the experiment.

Water containing fluorine above the level of 2.5 p.p.m., however, brought about marked changes in the teeth. There was a tendency for the permanent incisors of all sheep in the groups which received water containing 10 and 20 p.p.m. of fluorine to erupt earlier than those in the other groups. The teeth of the individuals in the 2.5 p.p.m. group were normal and those of the individuals in the 5 p.p.m. group had lesions so slight as to be of little importance: but obvious mottling appeared in the permanent incisors of the animals in the 10 p.p.m. group. The lesions in the incisors of five of the six animals in the 20 p.p.m. group were serious and the molars were mottled and selectively abraded.

The fluorine content of the bones increased with the quantity of fluorine ingested from 0.03 per cent. in the bone ash of the controls to 0.7 per cent. in the ash of the bones of those in the 20 p.p.m. group.

It is apparent from this experiment that the ingestion of water containing as much as 20 p.p.m. fluorine exerted little effect on the general health and productivity of the experimental sheep. As these animals were fed in pens on chaffed hay and crushed grain, the untoward effects on the teeth were of less importance than they would be under grazing conditions. Clearly, water containing more than 10 p.p.m. of fluorine should be regarded with suspicion, and water containing 20 p.p.m. should be considered definitely unsuitable for grazing sheep.

11. Minor Elements in Animal Nutrition.

The study of the physiological functions that minute traces of the heavy metals assume in animals has been continued with investigations both in the laboratory and in the field. Further study has been made of the limitations imposed on the health and productivity of animals and plants by conditions within the soils which lead to deficiencies of cobalt, copper, zinc, &c. During 1948-49 especial attention has been given to the effects that the chronic ingestion of molybdenum has on copper metabolism. The results from these researches prove unequivocally that the ingestion of moderate amounts of molybdenum precipitates more rapidly the untoward effects of copper deficiency in sheep on copper-deficient pastures. It is doubtful, however, if the quantities of molybdenum which are usually present in pastures seriously impair the health of sheep grazing on areas where the intake of copper varies, according to season, within the "normal" range of 7-10 mg./day. Experiments that are described below have thrown considerable light on the utilization of copper by animals.

(*a*) *Cobalt Deficiency.*—(i) *Cobalt in the Nutrition of the Rat.*—Attempts to induce a state of cobalt deficiency in the rat have indicated that the concentration of cobalt in the diet that is necessary to meet the requirement of the rat is certainly smaller than that necessary for ruminants. Three filial generations of rats have been raised while confined to a diet containing $<0.03\mu g.Co/g.$ dry wt., which concentration would certainly lead to the fatal consequences of cobalt deficiency in a sheep. The experiments are being continued and in an attempt to render unassimilable the small quantity of cobalt in the diet a study is being made of the effects of adding to the diet reagents which form association complexes with cobalt. The desirability of being able to induce cobalt deficiency at will in small laboratory animals has assumed considerable importance since the discovery that the anti-pernicious anaemia factor (vitamin B_{12}) is an association complex of cobalt.

Recent discoveries imply that cobalt is an essential element for all animals.

(ii) *The Physiological Function of Cobalt.*—The fact that ruminants require more cobalt than other animals and that sheep are particularly prone to cobalt deficiency has been mentioned previously, together with the report of the findings that cobalt introduced into the blood stream is ineffective in the sheep. It is probable that the symbiotic flora which inhabit the paunch are implicated in the deficiency syndrome which develops in ruminants. In order to determine whether this is so, abomasal fistulae have been established in eight ewes. These animals which are already in an incipient state of cobalt deficiency have been transported back to cobalt-deficient pastures where the effects of introducing cobalt into the abomasum will be observed. The reaction of these animals should prove unequivocally whether the micro-organisms of the rumen are involved.

(iii) *The Anaemia of Cobalt Deficiency in the Sheep.*—A study has been made of the anaemia which is an invariable symptom of cobalt deficiency in the sheep. Although this has many features in common with Addisonian pernicious anaemia and with other macrocytic anaemias of nutritional origin, our preliminary experiments have indicated that it will not respond to massive doses of concentrated liver extracts, introduced parenterally, or to similar therapy with pure anti-pernicious anaemia factor (vitamin B_{12}). Nor does therapy with relatively large quantities of pteroylglutamic acid exert any beneficial effect. A further experimental study is being made of this aspect of the problem in order to throw further light on the physiological functions of cobalt.

(iv) *The Site of Activity of Cobalt.*—The experiment to ascertain finally whether cobalt introduced into the blood stream may be of any benefit to sheep, which was mentioned in previous reports, has been completed. Experimental sheep depastured on deficient terrain at the Division's Field Station, Robe, South Australia, which received 7 mg.Co/week injected into their jugular veins all developed the cobalt-deficiency syndrome and were not significantly different at any time from those which were untreated, although the cobalt concentration in their tissues was greatly enhanced. Those which received the same quantity of cobalt *per os* remained normal and healthy throughout the whole period.

(v) *The Quantity of Cobalt Necessary for Complete Nutrition of the Sheep.*—A series of experiments with groups of sheep depastured at Robe Field Station has proved that 0.05 mg.Co/day in addition to the (approxi.) 0.035 mg.Co/day ingested in the fodder derived from the deficient pastures is enough to fulfil the requirements of growing sheep. The individuals of the group that received a supplement equivalent to 0.025 mg.Co/day administered *per os* thrice weekly, all developed the deficiency syndrome. This treatment merely delayed the course of the malady. The group that received a supplement equivalent to 0,05 mg.Co/day have maintained normal health and productivity and, over the first two years of observation, have not at any time differed significantly from the group treated with the equivalent of 1 mg.Co/day.

(*b*) *Copper Deficiency in Sheep and the Influence of Molybdenum on the Metabolism of Copper.*—The wide-spread occurrence of copper deficiency among flocks grazed in southern and Western Australia and the limitations imposed on wool production by the inability of the pastures to maintain a normal effective copper status in the sheep grazed on them have been discussed in previous reports. In southern Australia the malady appears to be the result of a deficiency of copper in the fodder as the copper content of the pastures is very low (3-4 μg.Cu/g.d.wt.). Similar maladies occur elsewhere, however, where the pastures apparently contain as much copper as those on "normal" terrain where disabilities due to copper deficiency are never experienced. Clearly, then, the utilization of copper is impaired by substances ingested along with it in the fodder available on these latter areas. Molybdenum has been indicted, on circumstantial evidence, and it is clear from experimental observations that the quantity of molybdenum present in some pastures may influence adversely the effective use of copper by the animal. The results from experiments that are reported here indicate the complications that may arise from the chronic ingestion of excessive amounts of molybdenum, but show that the quantities present in pastures are unlikely to bring about the profound effects that have been observed in flocks depastured on terrain where the copper concentration of the fodder is claimed to be relatively high. At this juncture it would appear that, under these latter conditions, other factors are responsible and that these impair the utilization of copper by the sheep more effectively than molybdenum.

(i) *The Influence of Chronic Ingestion of Molybdenum on the Utilization of Copper by Sheep.*—The experimental observations conducted at the Division's Field Station, Robe, South Australia, which were referred to in the previous report (Chapter V) have been continued. After 70 weeks of treatment observations of groups which have received the equivalent of 10 mg.Cu/day, 10 mg.Cu + 100 mg.Mo/day, and 10 mg.Cu + 50 mg.Mo/day, indicate that treatment with molybdenum has increased significantly the concentration of copper circulating in the blood but has had, as yet, no significant untoward effect on their general health or productivity. 100 mg.Mo/day administered to the groups of sheep which received no supplement of copper and which during the whole of this time were in negative copper balance has certainly led more rapidly to their depletion and has precipitated sooner the syndrome of extreme copper deficiency. The concentration of copper in the bloods of the molybdenum-treated group has remained paradoxically very significantly higher. It is clear that in these circumstances the copper in the blood and in the tissues does not function effectively. These experiments are being continued.

(ii) *The Influence of Chronic Ingestion of Molybdenum on the Concentration of Copper in the Livers of Grazing Sheep.*—Seven groups, each of six animals, selected at the beginning of the experiments to have practically identical mean concentrations of copper in their livers (determined by analyses of samples removed by biopsy) have been depastured at the Division's Field Station, Glenthorne, South Australia, and treated respectively with 0, 5, 10, 15, 20, 25, and 50 mg.Mo/day. The copper in the livers of the control untreated group decreased during the first nine months to approximately half of the concentration at the beginning of the experiment—the animals were probably in negative copper balance during a seasonal shortage of copper in the available fodder. The concentration of copper in the livers of the groups treated with molybdenum, however, was reduced to half that of the controls, irrespective of the quantity of molybdenum ingested. Clearly, a relatively small amount of molybdenum may, under certain circumstances, bring about a maximum effect. At this juncture the copper status of no animal in these groups has been depleted sufficiently to impair normal physiological function. The experiment is being continued.

(iii) *The Influence of Chronic Ingestion of Molybdenum on the Copper Status of the Rat.*—The production of copper deficiency in the rat which has been referred to in previous reports has allowed an intensive study to be made of the influence of molybdenum on the utilization of copper. An effective intake of 9 μg.Cu/day was proved to be just sufficient to meet the requirements of a growing rat: 1,000 μg.Mo/day superimposed on this has led to unmistakable symptoms of copper deficiency but paradoxically has increased both the concentration of copper in the blood and the concentration of copper in the liver. Molybdenum thus tends either to fix copper in a form which is not utilizable by the tissues, or antagonizes, by hindrance, the copper-containing enzymes.

(iv) *The Copper and Molybdenum Concentrations in Pastures.*—The comprehensive series of analyses of pastures which has been carried out during the past five years in this laboratory indicates that the severity of the copper-deficiency syndrome in grazing sheep is correlated with the copper content of the pastures, and not with the molybdenum concentration or with the ratio of this to the copper concentration.

(*c*) *The Amino-acid Constitution and Chemical Structure of Wool from Copper-deficient Sheep.*—The lesion in the wool fleece that results from copper deficiency has been discussed in previous reports. The follicles of a copper-deficient sheep fail to impart the natural crimp to the fibre, owing to a partial breakdown of the enzyme system responsible for the oxidative closure of the sulphydryl groups in the prekeratin. The morphological change in the fleece is incidental to much more profound changes in the molecular structure of the fibre. Wool from copper-deficient sheep differs markedly in physical properties from normal wool; the tensile strength of the fibres is less and the elastic properties are abnormal—the fibres, for example, stretch more easily than normal fibres when stress is applied and recover less rapidly when released.

In order to determine the reason for these changes the structure of the abnormal wool has been subjected to chemical and physico-chemical analyses. The amino-acid constitution has been shown to be changed very little from that of normal wool—the percentage of the basic amino acids, arginine, lysine, histidine, the serine content, and the methionine content of the fibres are unaltered in copper-deficient wool. The acid-combining capacity is slightly changed, however, and the concentration of cystine in the fibres is significantly reduced. This latter difference is considered insufficient to explain the profound alteration in the properties of the wool. Physical measurements suggest that the molecules in the abnormal keratin are less regularly orientated than in normal wool. The work is proceeding, as it is clear that a better understanding of this lesion will throw considerable light on the structure of keratin.

(*d*) *Field Experiments.*—The report on the distribution of cobalt and copper deficiency in South Australia which is being prepared in response to an invitation from the South Australian Department of Agriculture for use by the Advisory Services is now being drafted. The maps are completed.

(i) *Robe.*—Many of the experiments mentioned in the preceding sections have been conducted on the Field Station at Robe, South Australia. In addition to these, the following experiments have been carried on during the period under review.

(1) *The effect of dressing copper-deficient pastures with copper sulphate*: The ewes depastured on the copper-deficient tracts which were top-dressed with 14 lb. $CuSO_4.5H_2O$/acre in 1940 have continued to lamb normally. This treatment has prevented them from becoming depleted to the stage at which enzootic ataxia becomes prevalent in the lambs, but the quantity of copper available from pasture is insufficient to meet the full requirements of the ewes—there are definite copper-deficient lesions in the wool of the experimental animals which have not received an additional supplement of copper.

(2) *The effect of dressing cobalt-deficient pastures with cobalt sulphate*: A dressing of 1 lb. $CoSO_4$/acre applied in 1944 to the deficient pastures has failed to provide sufficient cobalt to maintain normal health in sheep grazed there.

(3) *Copper deficiency and wool growth*: In previous reports reference has been made to the chemical mechanisms within the wool follicles which become impaired when the animal becomes short of copper. A striking change in the character of the wool is the first manifestation of copper deficiency. The follicle fails to impart crimp and, in pigmented sheep, fails to produce pigment. In experiments carried out during the past year, black sheep have been depleted of copper until their fleeces were white and without crimp. Supplements equivalent to 2.5 mg. Cu/day partially restored the crimp but had no influence on pigmentation. Supplements of 10 mg.Cu/day dramatically restored both crimp and pigmentation.

(4) *The effect of dried liver on cobalt deficiency*: A group of very young lambs which received supplements of 40 g. dried sheep's liver + 1 mg.Co/day grew normally, but individuals in the control group, which received only the liver, died of typical cobalt deficiency. When lambs in the latter group had developed the deficiency syndrome, they responded normally to treatment with cobalt.

(ii) *Keith.*—A higher concentration of copper has been maintained in the lucerne by the manurial dressing of 7 lb. $CuSO_4.5H_2O$/acre applied in 1943. Experimental sheep grazed on this area have maintained a normal copper status and have produced normal wool, whereas the individuals in the control group of sheep grazed on immediately adjacent paddocks of similar pasture that was not dressed with copper have become depleted sufficiently to lead to obvious lesions in their wool.

In the spring of 1948 cobalt deficiency became manifest in the flocks on this property and in the surrounding district for the first time since 1941. Analyses of pastures have confirmed a profound deficiency of cobalt at that time. This is an important confirmation of observations discussed previously in these reports. Seasonal change in climatic conditions may on occasions precipitate acute deficiencies of cobalt (and of copper) in certain areas where the pastures at other times provide the full nutritional requirements of the grazing flocks.

(iii) *Borrika.*—During the past year no obvious signs of copper deficiency have appeared in the experimental flock grazed on the untreated pasture of this area. Thus for the fourth successive year no signs of deficiency have appeared on this area where obvious deficiency occurred in 1941, 1942, and 1943.

(iv) *Glenroy.*—This station is on incipiently cobalt-deficient terrain where on occasions the flocks suffer the acute syndrome. No signs of cobalt deficiency have appeared in the experimental flocks there since the very serious outbreak in 1944.

(v) *Kybybolite.*—No response to cobalt or to copper supplements has been observed in the experimental flocks on this area.

12. Physiology of Reproduction.

(*a*) *Inactivation of Gonadotrophin.*—Work on the inactivation of gonadotrophin has continued (*see* Chapter V., Section 3 (*f*) (i)).

(*b*) *Mechanism of Fertilization.*—Studies have been started on the preservation of the fertility of spermatozoa for relatively long periods at room temperature and the fertilization of the ovum *in vitro* (*see* Chapter V., Section 3 (*f*) (ii)).

(*c*) *Cyclical Activity in the Reproductive Tract of the Mature Non-pregnant Ewe.*—Sexual receptivity has been found to be associated with the appearance of copious amounts of thin mucus in the vagina, a sharp fall in the vaginal pH, enlargement and congestion of the external aspect of the cervix, and some patency of the external cervical orifice; and it has been followed by the appearance of vaginal contents with a cheesy consistency, a gradual rise in the vaginal pH, and a regression of the enlargement, congestion, and patency of the cervix. However, the level of expression of these several features and the extent and regularity of the cyclical changes have varied widely in individual animals.

(*d*) *Seasonal Variation in Fertility.*—Three matings of ewes from the one lot to the same rams at four-monthly intervals provided distinctly different lambing results. The most outstanding features were (i) the failure of a high proportion of ewes mated from mid-August to mid-October to bear lambs; and (ii) the occurrence of a high proportion of multiple births in the ewes mated from mid-April to mid-June along with an absence of multiple births in the ewes mated from mid-December to mid-February. These differences are unlikely to have been associated with any differential "flushing" effect. There was a high incidence of oestrus among the ewes which failed to bear lambs from the August-October mating.

(*e*) *Development of Reproductive Activity in Young Ewes.*—Observations were made on three groups of lambs dropped at four-monthly intervals. Oestrus was exhibited earliest by the lambs dropped from September to November, later by the animals dropped from May to June, and latest by the animals dropped from January to March. This variation in the age of the first exhibition of oestrus is, no doubt, associated with the time of the year at which the animals were born in relation to the normal sexual season among animals of this breeding. Conception occurred prior to 227 days of age in all of these animals and considerably earlier than that in some of them—as early as 151 days in one. It occurred on the first occasion on which some of them mated and within three months of the first mating in the others. In those animals in which gestation periods were well defined they were somewhat longer than usual—154 to 163 days. Cyclical changes in the vaginal pH and in the appearance of the cervix in the young ewes were similar to those in the adult animals, but changes in the amount, appearance, and consistency of the vaginal contents were more irregular.

13. Breeding and Genetical Studies.

(*a*) *Inbred Flocks of Australian Merinos.*—Further levels of inbreeding have been reached in all five of the inbred flocks at the F. D. McMaster Field Station. Relative fertility, size, and vigour continue to decrease n all groups. One group now traces its ancestry rincipally to a single foundation ewe which was highly ertile and had a large number of female progeny.

Several characteristics of fleece samples from the heep have been measured. Although these data will ot be exhaustively analysed until their number is ncreased, preliminary examination has not disclosed niformity of characterization within most of the roups. The single exception is for the group headed y the ram M3 and, to a large extent, having ancestry raceable to the one ewe which has been mentioned. In his instance, the group is characterized by uniformly ow density of fibre population as compared with the ther inbred groups.

Physical abnormalities observed in lambs born in the nbred flocks this year were atresia ani in one lamb nd the birth of another lamb having single toes only n its front feet. Other abnormalities previously eported were not observed this year. Seventeen f these inbred sheep have been passed to the Parasitological Section of the McMaster Laboratory for ritical experiments with relatively small numbers of nimals.

(*b*) *Investigation of Heterosis.*—Additional rams ave been sent from the F. D. McMaster Field Station o the National Field Station, "Gilruth Plains", in onnexion with this investigation. The plan calls for he breeding of rams having a range of Wright's oefficient of inbreeding from zero to as high as possible. Five families are now represented in the experiment y rams having coefficients of inbreeding ranging from) to 25 per cent., the levels of inbreeding covered being), 6.25, 12.5, and 25 per cent. Further rams having still higher coefficients of inbreeding will be included in the experiment as they become available.

(*c*) *Inheritance of Component Characteristics of Fleece Weight.*—The investigation of methods of inheritance which control yield, staple length, fibre diameter, and density of fibre population has been commenced. Border Leicester, strong-woolled South Australian, fine and superfine New England Merinos are being used as experimental animals. The first of the series of planned matings commenced in May, 1949.

(*d*) *Inheritance of "Hairiness".*—Experimental matings are still being made in the investigation of the inheritance of this characteristic in Merinos. Examination of data from F1 progeny indicates a possible relationship between the animal's fuzzy-tip score and the coefficient of variation of fibre diameter in wool samples from both midside and breech areas. The percentage of medullated fibres in samples of wool from both the midside and breech areas did not appear to be in any way related to fibre diameter or its co-efficient of variation.

(*e*) *Study of Breeding Systems.*—The broad objects and methods of this long-term investigation at the National Field Station, Cunnamulla, Queensland, have been reported previously. During the year the stage was reached when the performance in regard to conformation and wool production of the progeny, from the initial mating in 1947, could be measured, and the figures so obtained were used as the basis of selection for the 1949 matings. Some most promising families have been isolated.

(*f*) *The Study of Strains of Merino Sheep in Several Environments.*—These studies are spoken of shortly as "strain trials". The several strains of sheep have been selected and placed at "Gilruth Plains", Queensland, and Armidale, New South Wales, respectively. Five strains are being studied at "Gilruth Plains", viz. (i) and (ii) Peppin medium fine (iii) Non-Peppin fine (iv) Non-Peppin medium-fine, and (v) Non-Peppin strong. At Armidale the fourth group is not represented.

14. BIOLOGICAL STUDIES OF THE SKIN AND WOOL GROWTH.

(*a*) *Comparative Breed Studies.*—An experiment has been commenced to study sheep of Merino, Corriedale, Polwarth, and Lincoln breeds under laboratory conditions where individual animals can be fed on a uniform high-quality ration and the fleece growth accurately measured. Of the six animals in each breed being studied, four are kept in individual pens and two are kept at pasture in the role of reserves and as a comparison in performance under free grazing conditions. The object of this experiment is to analyse the main differences in the wool-producing capacity of these four contrasting breeds. In an earlier experiment a relationship was established between wool-growth rate, nutrient intake, and wool-producing capacity, which, it was suggested, might hold for all breeds of sheep. The current experiment is designed to test the application of this theory on a wider range of sheep types as a further step towards establishing standard laboratory methods of comparing fleece production of sheep for genetic purposes.

(*b*) *Classification of the Hair Follicle Group in Sheep as a Genetic Aid.*—It has long been established that the fleece is grown from follicles which are organized into a definite group arrangement. The nature of this grouping has within recent years become clear, so that it is now possible to describe the hair follicle group in sheep as a definite measurable entity. Evidence is accumulating that this follicle group varies only within definite limits for each breed and species of sheep and that of all the attributes of the skin and fleece, the numerical size of the group is one of the most "strongly inherited".

It is now possible to substitute the skin section for the fleece staple in the comparative breed studies as a means of estimating fibre population density, mean fibre thickness, and fibre uniformity. The use of the skin section for certain types of genetic work on fleece characters in sheep is now regarded as essential.

(*c*) *The Stability of the Follicle Group as a Measure of Inherent Differences in the Follicle and Fibre Population of the Skin.*—If the follicle group is to be used as a basic criterion for the comparison of sheep, it is important to know how stable it is in the face of variations in the environment. Since the most important single factor likely to affect it is the general plane of nutrition, the effect of this was studied experimentally. From these experiments, it has been shown that only the lowest and most adverse nutritional plane produces any demonstrable effect on either the numerical ratio or the fibre thickness ratio. Since from present knowledge it is most unlikely that sufficiently low planes of nutrition to produce such effects would normally be encountered, it is clear that the follicle group may be used with considerable confidence in experimental breeding. Consideration of results so far obtained in the course of comparative breed studies shows that the numerical ratio and the fibre thickness ratio provide two of the most unequivocal methods of distinguishing differences in the skin and fleece of individuals, flocks, and breeds.

(*d*) *An Analysis of Skin and Fleece Characters in the Ewe Progeny of Three Top Sires in an Australian Merino Stud.*—A study has been made of the ewe progeny of three outstanding sires in an important Australian Merino stud. Skin and fleece samples were collected from the first 35 ewe progeny sired by each of the rams, and born in the spring of 1946. These progeny were sampled as young ewes before classing in March, 1948, and therefore represented a true random sample of female offspring of the three sires. The most notable feature of the measurements made on these samples was the marked contrast in nearly all fleece characters between the progeny of two of the three rams.

The situation disclosed is typical of the genetic problems which face the breeder in a high-class Merino stud at the present time, and demonstrates the value which the comparison of unselected progeny groups can have, when appropriate measurements are used.

(*e*) *Skin Grafting in Sheep.*—As a preliminary to further studies on the physiology of the wool follicle and the genetics of the hair follicle group, a simple surgical technique has been established for small autografts in sheep, that is, the grafting of skin from one part of the body to a new site on the same animal. The regressive changes in the follicle population which follow this procedure are being studied. This work will be developed further in association with the tissue culture programme.

15. Sheep Diseases.

(*a*) *Caseous Lymphadenitis of Sheep.*—The experiments on the protective value of annual vaccination one month before the sheep are shorn, and of placing sheep directly "off shears" into a clean, rested paddock, have been continued. Each year, up to the present, a new batch of sheep has been added, but none of these batches has yet come to slaughter, as the experiments are continued on each batch for a period of four years.

(*b*) *Toxaemic Jaundice of Sheep.*—The investigations have been continued with the active co-operation of the staff of the Veterinary Research Station, Glenfield, New South Wales. Those centred at the Field Station, Barooga, New South Wales, were designed for the more intensive study of heliotrope poisoning. The plant has been found to contain one or more substances which damage the liver of the sheep. The effects are slowly progressive over a period of about six months and they lead to few or no deaths after the animals have grazed the plant for the first season. They render the animal susceptible to the consumption of the plant in the following year. Again the damage to the liver cells is slowly progressive, but within a period of about six months after the grazing has ceased 50 per cent. or more of the flock may have died with an atrophic fibrosis of the liver. A small proportion of the sheep that die may develop the haemolytic crisis of chronic copper poisoning as a terminal event. During the year the Division of Industrial Chemistry undertook the isolation and identification of the alkaloids present in *Heliotropium europaeum.* The presence of lasiocarpine was confirmed but the work was not completed.

During the year a study of the effect of sheep grazing a pasture dominated by subterranean clover on the copper status of the animals was carried out on a property in the Adelaide Hills district, South Australia. The results showed a steep fall in the molybdenum content of the clover over the period from June to September, although the copper concentration in the plant remained steady. Under these conditions the sheep grazing the pasture acquired a high storage level of copper in the liver but chronic copper poisoning did not occur.

Progress was made during the year in the preparation of a clover pasture under irrigation for a more systematic study of the factors leading to chronic copper poisoning in sheep grazing subterranean clover pastures on some soils in some seasons.

Further work on supplements of molybdenum to the diet of sheep has confirmed the earlier results which indicated that this element can suppress the amount of copper stored in the liver. However, it was also found that if sheep have grazed heliotrope, a supplement of molybdenum brings about a higher death-rate by increasing the severity of damage to the liver.

A report for publication was prepared on the co-operative investigations by the Investigation Committee.

(*c*) *Sheath Rot.*—Three sheep have been fed a high protein diet for the greater part of the year. Two of them developed lesions indistinguishable from sheath rot, and the third showed extensive, persistent ulceration about the orifice but without internal involvement of the prepuce. A visit was paid to a property in New South Wales where the owner had incised the skin above the prepuce in an attempt to make the sheath more pendulous, hoping that this would permit better drainage of urine and prevent pizzle-strike and sheath rot. The effect of the operation varied a good deal from sheep to sheep and no conclusions could be drawn. If the operation were properly performed so as to drop the prepuce further from the abdominal wall it might conceivably affect the incidence of pizzle-strike but, from field observations, it seems highly improbable that it would reduce the incidence of sheath rot.

(*d*) *Pregnancy Toxaemia.*—Studies on metabolism in sheep are providing basic information of particular value in this connexion. Some preliminary observations are also being made on the adrenals of normal sheep and on the clinical, bio-chemical, and pathological features of the so-called "adaptation syndrome" in the sheep, and these will be compared with those of pregnancy toxaemia.

(*e*) *Fleece Rot.*—The incidence of this condition in the F. D. McMaster Field Station flock has been examined during the past three years. Examination of the data suggests that the incidence of fleece rot is greatest when the animals are continuously wet under conditions of high atmospheric humidity. The incidence was greatest in young and least in old sheep. When sheep of equal ages from seven family groups were compared, it was found that in two groups the incidence of fleece rot was significantly low and in two groups significantly high compared with the remaining groups. It appears that neither relatively great density nor relatively low clean scoured yield are primary predisposing factors.

16. Internal Parasites.

(*a*) *Studies of Anthelmintics.*—Phenothiazine proved somewhat less effective against the large-mouthed bowel worm, *Chabertia ovina,* than it is against the nodule worm, *Oesophagostomum columbianum.* The results suggest that the drug may affect them only when they are feeding in the lumen of the gut and not while they are attached to the bowel wall. Examination of nodule worms passed with faeces after treatment with phenothiazine suggested that the drug so affects the parasite that it cannot retain its position in the gut and is swept away into the faecal stream.

Transfusion to two sheep of 200 ml. of blood from a third sheep, which had been dosed 24 hours previously with 50 g. phenothiazine, had no anthelmintic effect, although phenothiazine derivatives were excreted in the urine of the transfused sheep within two hours.

There was no appreciable response to monthly treatment with phenothiazine of lightly infested weaners on green oats during the winter of 1948 in Tasmania.

Hexachlorethane, administered into the rumen, was highly effective against *Haemonchus contortus* and showed some effect against *Trichostrongylus* spp. but was relatively ineffective against *Oesophagostomum columbianum.* It was also effective against the adult stomach flukes of sheep and cattle. *Paramphistomum* spp. and *Cotylophoron* spp.).

Lead arsenate is relatively insoluble and hence can administered in much larger doses than are possible ith soluble arsenicals. Doses of 0.5–2.0 g. into the imen were usually effective against *Haemonchus con-rtus* but not against *Oesophagostomum columbianum.*

A number of drugs was tested and found ineffective r ruminal injection.

(*b*) *Studies on Resistance to Nematode Infestations.* -Four groups of sheep were infested with *Tricho-rongylus* spp. by several doses of infective larvae at fferent intervals. Three months later, all these heep were given a further dose of larvae. There were o striking differences in response to the challenge ose. The results of this trial suggest that individual heep may be inherently more resistant, and others nherently more susceptible, to trichostrongylosis. To etermine the effect of age on resistance to *Tricho-rongylus* spp. four groups of sheep aged 12, 15, 21, nd 25 months, which had been penned since weaning, ere given a single large dose of larvae. Comparable egrees of infestation resulted in the groups aged 12 nd 15 months but the groups aged 21 and 25 months howed considerable resistance. This confirms field oservations. Some sheep infested with *Trichostron-ylus* spp. showed abrupt loss of the initial infestation hen dosed with larvae of the same species, suggesting hat the "self-cure" phenomenon may play a part n the epidemiology of trichostrongylosis as well as of aemonchosis.

Continuous grazing of weaners on green oats or Vimmera rye grass during the winter months at rmidale has, in three successive trials, been associated ith well-marked loss of nodule-worm infestations. n a trial with infested weaners on green oats at the IcMaster Field Station, during the winter of 1948, o comparable effect was found, although the nature f the faeces and rate of gain in body-weight were imilar to those observed in the Armidale trials. During rials with weaners wintered on green oats in Tasmania here was some indication at Cressy that infestations ith the large bowel parasites, *Chabertia ovina* and *esophagostomum venulosum,* declined, but no such ecline occurred in a similar trial at "Frodsley". At oth centres, however, the improved nutrition provided y green oat grazing was reflected in lower levels of ork infestation, especially in regard to *Tricho-rongylus* spp.

(*c*) *Serological Studies on Resistance and Immunity o Nematode Infestations in Sheep.*—The eggs, larvae, nd immature adults of *H. contortus* yield potent anti-ens, whereas mature adults do not. With *Tricho-trongylus* spp., on the other hand, both larvae and dults yield potent antigens. This is reflected in the act that the main antibody response to *H. contortus* ccurs shortly after the administration of larvae, hereas both larval and adult forms of *Tricho-trongylus* spp. stimulate antibody formation. Sheep ged fourteen months and eighteen months showed an arlier antibody response to *Trichostrongylus* spp. han sheep aged nine months, which accords with field bservations that older sheep are more strongly resistant o these parasites. In some sheep to which *Tricho-trongylus* larvae were administered there was no etectable antibody response, nor did the infestation evelop, suggesting that factors other than the forma-ion of complement-fixing antibodies are concerned with esistance in certain cases.

It was shown that a lipid, which is common to many arasitic nematodes, is an essential constituent of the oiled antigens used in these investigations. Hence, ntigens prepared from several different nematodes ive cross reactions with natural antisera to *I. contortus.* These cross reactions, however, do not ause confusion in practice. Prior extraction of lipid enabled more specific artificial antisera to be prepared against particular nematodes. When infective larvae of *H. contortus* are administered to sheep already infested with either *H. contortus* or *Trichostrongylus* spp. the titre of complement-fixing antibody rises and the existing infestation is eliminated or egg-count is suppressed. Larvae of *Trichostrongylus* spp. have a similar effect upon *Trichostrongylus* infestations but not upon *H. contortus* infestations.

The intramuscular injection of an alum-precipitated vaccine prepared from *H. contortus* larvae gave good serological responses but did not protect the host against infestation. The intravenous injection of formalinized suspensions of ground larvae also gave a marked antibody response and there was some evidence, from faecal egg counts, that the existing *H. contortus* infestation was reduced.

Examination of sera from some 30 calves grazing under natural conditions showed a positive correlation between reactions to the complement fixation test and the age of the calves. The sera of five calves reared in a worm-free environment were all negative to this test. These findings are probably related to the fact that the common nematode infestations in calves reach a peak during the first few months of life, after which there is relatively strong resistance, due either to acquired immunity or to age.

(*d*) *Epidemiological Investigations at Armidale.*—These studies, which depend mainly on finding the correlations between variation in climatic conditions and changes in the intensity of worm burden, have been continued and during the year were extended to include newly-born lambs. Observations on these lambs showed that within four weeks of birth 70 per cent. carried Coccidia and 50 per cent. adult Nematode worms.

(*e*) *Winter Feeding of Weaners.*—Further work at Armidale confirmed the efficacy of winter grazing on green feed oats in reducing infestation of nodule worms in weaners, as compared with comparable animals grazed on rather more productive winter pastures composed of Wimmera rye-grass in one case, and *Phalaris tuberosa,* red clover, and subterranean clover in another. The effect was not directly associated with weight gains by the weaners as the latter two groups showed considerably better figures in this respect than did the group grazed on the oats.

(*f*) *Parasite Physiology and Toxicology.*—Work in this field has continued within the Division of Animal Health and Production. It is described in Chapter V., Section 3 (*d*).

17. External Parasites.

(*a*) *Bionomics of the Body Louse of Sheep* (*Damalinia ovis*) *and the Foot Louse of Sheep* (*Linognathus pedalis*).—This work was terminated early in the year and the results have been prepared for publication.

(*b*) *Control of Ectoparasites of Sheep.*—Benzene hexachloride dips at concentrations containing 0.007 to 0.15 per cent. gamma BHC effectively eradicated foot louse infestations in a trial in which a power spray plant was used as a combined spray and footbath. Results of previous studies in the use of DDT and BHC sheep dips were prepared for publication. Crude BHC containing approximately 13 per cent. gamma isomer was found to control body louse infestation when administered to sheep by mouth. The doses tested ranged from 0.25 to 1.5 g./kg. of body weight. Unfortunately, the drug is toxic for sheep and the minimum dose which, in the small number of animals used, destroyed the louse infestation (0.5 g./kg.) induced severe nervous symptoms and loss of appetite for some days in some of the sheep. Higher doses actually killed some sheep and lower doses did not eliminate the infestation. Many keds present on the dosed sheep were killed but some survived to continue the infestation.

18. Sheep Blowfly.

(*a*) *Insecticides for Protection against Body Strike.*—In collaboration with the Division of Animal Health and Production, the Division of Entomology continued insectary tests on the effectiveness of applying insecticides to the tip of the fleece as a protection against body strike. DDT gave better protection than any other insecticide tested. In 2 per cent. concentration it gave virtually complete protection for many weeks; in 1 per cent. concentration the protective period was shorter, although valuable protection was generally given for several weeks. BHC also gave valuable protection when applied in concentrations usually considered rather high for this insecticide, 0.5 per cent. gamma isomer giving a degree of protection similar to 1 per cent. DDT. Intermittent artificial rain amounting to 17 inches did not affect the protection afforded by 1 per cent. DDT or 0.5 per cent. BHC over a 64-day experimental period. Chlorinated camphene gave some protection, but it was less effective than DDT, and "Toxaphene" did not give valuable protection. A noticeable feature of the DDT treatments was their extremely long partial protection after some oviposition was permitted, an effect which was not as marked with other insecticides.

None of the insecticides had any ovicidal effect. However, BHC was extremely toxic to young larvae, the vapour killing them rapidly, even when contact with the solid material was not permitted. None of the other insecticides exerted a similar effect.

The Division of Entomology is co-operating with the Queensland State Department of Agriculture in field trials of surface applications of DDT and BHC in the Stanthorpe-Texas area of Queensland. The experiments conducted so far have been inconclusive, because of the low incidence of body strike in flocks in the experimental area. As part of a larger trial, observations were carried out in south-eastern Queensland by the Division of Animal Health and Production on the value of the application of DDT or BHC to the fleece in the prevention of body strike in sheep. A relatively wet February had resulted in no strikes and the preparations were applied at the end of March. In April, 20 points of rain fell, and in May there were 172 points. In June, 78 points fell on four wet days. A small incidence of body strike occurred in May and June. The incidence was 7.4 per cent in 1,373 weaners, 1.1 per cent. in 2,262 breeding ewes, and 0.5 per cent. in 2,651 wethers. In 352 hoggets 5.1 per cent. of strike occurred, but in 238 hoggets treated with DDT and in 215 treated with BHC, strikes did not occur.

(*b*) *Lamb-marking Dressings.*—Further observations were carried out on dressings for the prevention of fly-strike in wounds following lamb-marking. The dressing containing boracic acid, citronella, and bentonite, now called "Borocit", has continued to give good results. This dressing was compared with several preparations containing dimethyl phthalate which proved to be good, but inferior to "Borocit". Tests were also carried out with a proprietary BHC preparation by dipping the rump of the sheep before docking. Over 50 per cent. of the docked tails were struck in the wounds but the strikes did not spread. Under the same conditions "Borocit" proved highly efficient.

(*c*) *Taxonomic Status of the Australian Sheep Blowfly.*—Work by the Division of Entomology on this problem is reported in full in Chapter IX., Section 3 (*b*).

19. Other Activities.

(*a*) *Neo-natal Mortality in Lambs.*—Following the preliminary observations reported last year a systematic investigation of this problem has been undertaken. Results to date indicate that low natural increase in the flock of Merinos under observation was due to a high neo-natal mortality rather than to a low birth rate. The reduction of this loss was a problem for solution by animal husbandry methods as no infectious disease was involved, and all lambs born apparently had the capacity to survive. Failure to suckle in the case of the lamb, and desertion, particularly by maiden and weak ewes, accounted for a large proportion of the loss.

(*b*) *Fleece Analysis Laboratory.*—(i) *Routine Measurements.*—This Laboratory has continued to perform the measurement of the characteristics of fleece samples submitted by the various Divisions of the Organization. During the year some 23,000 measurements were made covering scouring tests, fibre diameter, fleece density, crimp, and staple length.

(ii) *Development and Investigational Work.*—An automatic fibre-length analyser has been developed to a point where it can be used reliably for obtaining a fibre-length analysis of sound wool and for counting the number of fibres in the staple under test. The principle of operation is that the fibres at the tip and the base of a small staple are cemented together, and the staple then stretched until all the fibres break. The impulses on breaking are counted automatically by an electronic device. By noting the number breaking in each length interval, the lengths of the fibres present in the staple are determined. Although the device has certain limitations in its present form, it is useful for distinguishing samples with a high variation in fibre length from those which are more uniform in this character.

VIII. CATTLE.

1. General.

Cattle, both for beef and for dairy products, play an important part in the Australian economy. New prospects for beef exports to the United Kingdom have opened up the need for additional research into problems of beef production in north Australia. Already beef is the main industry of this region which for climatic and agrostological reasons is not suitable for sheep raising.

The Organization's work on cattle problems has been carried out within the Division of Animal Health and Production (mainly in its Animal Health Laboratory Melbourne, and its Veterinary Parasitology Laboratory Queensland) and is described in the remainder of this Chapter.

The Division of Entomology has been concerned with work on the cattle tick (*see* Section 4 (*a*)-(*d*) below) The pastures work of the Division of Plant Industry (*see* Chapter III.) is naturally of great importance to the cattle industry.

2. Cattle Diseases.

(*a*) *Pleuropneumonia of Cattle.*—Attempts to immunize cattle against pleuropneumonia by means o non-living vaccines were not successful even though relatively enormous dose was given subcutaneously, viz. the organisms from 4l. culture suspended in 20 m saline and killed with 0.4 per cent. formalin. Living vaccine, on the other hand, in a dose of 0.2 ml. at th tip of the tail routinely produces almost 100 per cent immunity and much smaller doses are sufficient. When the non-living vaccine was combined with "Aquaphor (a cholesteryl ester preparation) and with kille *Mycobacterium tuberculosis*, very much better com plement fixation reactions were obtained (titre=640 than without these adjuvants (titre=80) but, whe the cattle were tested for resistance to infection by nebulized culture three months later, all developed severe infection similar to controls. A routine test of the vaccine strain V5 showed that it is still highly efficient. Thirty cows vaccinated at the tip of the tail with 0.2 ml. gave normal serological response and mild tail reactions. Thirty which had been vaccinated with 1 ml. of *Br. abortus* "Strain 19" vaccine twelve months earlier during another experiment were also used, but although normal mild local reactions followed, twelve failed to give any serological response and the other eighteen gave lower titres than usual. It appeared that previous tail vaccination with *Br. abortus* "Strain 19" interfered with the serological response to pleuropneumonia vaccination. However, when challenged later by nebulized culture, both groups of 30 animals resisted infection, whereas of 30 controls, three died, 26 showed advanced lesions at autopsy and only one resisted.

Against six Australian strains of diverse origin, complement-fixing and agglutinating antisera were prepared in sheep, each of which received repeated injections during three months of antigen prepared from the separated organisms from 10l. of culture, killed with formalin and reinforced with "Aquaphor" and killed *Mycob.* tuberculosis. Cross agglutination and complement-fixation did not reveal evidence of antigenic differences between the strains.

During the year, 366,000 doses of V5 vaccine were distributed and complement-fixing antigen was provided cost-free to Government authorities in Victoria, New South Wales, Queensland, Sudan and Kenya.

(*b*) *Tuberculosis of Cattle.*—Further progress has been made in the study of the detection of tuberculous animals not reacting to routine intradermal tuberculin tests. The modified subcutaneous test ("short thermal test") mentioned in the previous report has proved of value in the field as a supplementary test for their detection. Moreover, it appears to have a useful application in constantly-retested herds in deciding the status of cattle giving doubtful reactions to the routine tests. Of 133 tuberculous cattle which were submitted to the supplementary short thermal test, 122 (92 per cent.) reacted. Of 62 reactors to the routine intradermal test in which no visible lesions were found at autopsy, only ten had reacted to the short thermal test. Judgment based on the much more accurate short thermal test would have saved from slaughter 84 per cent. of the animals in this group. In comparing the results of studies of the disease in the Australian environment with those obtained by workers overseas, further data on the routes of infection are being collected. Furthermore, the reactions of tuberculous and non-tuberculous Australian cattle to P.P.D. products issued from Weybridge for official use in the United Kingdom, and those produced by Commonwealth Serum Laboratories, synthetic-medium tuberculins are being compared. The study of the tuberculin test is being extended to cattle, sheep, and rabbits artificially sensitized with killed tubercle bacilli.

(*c*) *Mastitis in Dairy Cattle.*—The original experimental herd, which is now maintained as a producer unit, is still under supervision. It was used during the year in trials of newer preparations of penicillin and for an experiment on the control of the spread of *Str. agalactiae.* Several preparations of procaine-penicillin in peanut oil with the addition of (*a*) aluminium monostearate, (*b*) 4 per cent. white beeswax, or (*c*) 25 per cent. yellow soft paraffin, were compared with the "standard" calcium penicillin in peanut oil with the addition of 25 per cent. soft paraffin. All the preparations were placed in collapsible tin tubes with applicator tips for direct injection into the teat canal. All the preparations were found to be equally non-irritating to the secreting tissues but those containing procaine-penicillin maintained a higher and more prolonged level of penicillin in the secretions of the quarters. In another experiment preparations containing calcium penicillin and crystalline penicillin G (750 and 1,550 units per mg. respectively) were found to be equally good both in maintaining the levels in the milk and in absence of irritant effects.

During the year an experiment was carried out to determine the value of hypochlorite in preventing the spread of *Str. agalactiae* by the milking cups. In the controls (Group A) milk from an infected cow was used to contaminate the cups, which were then used serially, without being washed, on each set of three cows. In another experimental group (Group B) the contaminated cups and the hands of the milkers as well as the teats of the cows were treated in the recommended way with hypochlorite solution. In a third experimental group (Group C) the cups were not deliberately contaminated before treatment with hypochlorite. The experiment was continued over a period of eight weeks. Most of the infections in all the groups were acquired in the first two weeks. Group A showed 33 per cent. of very low count "occasional occurrences" without abnormal leucocyte count and 58 per cent. of persistent moderate or high count with high leucocyte count; for Group B the corresponding figures were 31 per cent. and 8 per cent., and for Group C, 28 per cent. and 8 per cent. Group A showed 42 per cent. clinical mastitis; Group B, 6 per cent; and Group C, none. The results of the trial indicate the value of the recommended shed hygiene.

(*d*) *Brucellosis in Cattle.*—It has already been confirmed that *Br. abortus* "Strain 19" vaccination of cattle offers a practicable method of controlling contagious abortion in cattle (20th Annual Report). In the 19th Annual Report it was reported that intracaudal vaccination with 1 ml. gave serological evidence of possessing advantages over standard subcutaneous vaccination with 5 ml. An experiment was begun during the year to determine whether or not intracaudal vaccination is as effective as standard vaccination in protecting cattle against infection and abortion. Vaccination was carried out between the eighth and tenth month. As in the previous experiment, the mean agglutination titres after intracaudal vaccination exceeded those of the subcutaneous vaccination with the five-fold larger dose. It is being arranged that, in challenging immunity twelve months after vaccination, groups approximately 60 in number, with unvaccinated cattle of the same age, will be available for exposure in an environment heavily contaminated by aborting cattle with which they will be in close contact.

(*e*) *Haematuria vesicalis.*—Estimation of phenols in urine of cattle from unaffected and affected areas has revealed that some polyphenolic compounds present in the first are not present in the second, but the significance of these differences has not yet been determined. Methods have been perfected for the estimation of aromatic amines in bovine urine by the use of a modification of the method for determining sulphonamides. Suggestive differences have been found between the urines from unaffected and affected areas, and these are being further studied by means of paper chromatography.

(*f*) *Anaplasma centrale.*—The strain of *A. centrale* has been further propagated in calves.

3. INTERNAL PARASITES.

(*a*) *Onchocerca gibsoni* (*Beef Nodule Worm*).—Following the preliminary investigations previously reported, further work on this problem has been suspended until an insectary is available for transmission experiments.

(*b*) *Epidemiology of Parasitic "Gastro-enteritis" of Calves.*—These studies have been continued and during the year were extended. The species concerned have been confirmed as *Haemonchus contortus, Bosicola radiatum, Bunostomum phlebotomum,* and *Cooperia* spp. (*C. punctata* and *C. pectinata*). Every calf examined has been infested with these species though the degree of infection has varied widely. In sequence according to age, calves become infested with Strongyloides, *Cooperia, Haemonchus, Trichostrongylus* and *Ostertagia, Bunostomum,* and *Bosicola. Cooperia* larvae were first seen at three to four weeks, *Haemonchus* at six to eight weeks, and *Bunostomum* and *Bosicola* at two and a half months. The season of maximum abundance of particular species varies. With each of the species mentioned, the infestations gradually increased to a maximum, then gradually declined, and thereafter remained on a very low plane, despite the fact that larvae were plentiful and infestations of younger calves continued to increase. Conditions during the late summer and autumn of 1949 were particularly favorable for the increase of infestations in calves. Serious outbreaks occurred in the vicinity of Brisbane and elsewhere. Usually such outbreaks are not reported before mid-winter.

(*c*) *Helminth Infestations in Adult Cattle.*—It is recognized that in Australia and elsewhere, parasitic gastro-enteritis in adult cattle, arising from infestations of *Haemonchus, Bosicola,* and *Bunostomum,* is rarely seen. It has been suggested that by grazing adult cattle and calves together, large numbers of larvae would be destroyed by ingestion by the adult animals, and in this way, serious infestations in the younger animals might be prevented. This matter is being investigated. The evidence obtained to date indicates that these infestations are in general on a low plane and, at first sight, that adult cattle may be of little importance as reservoirs of infestation for calves, except in the case of *Haemonchus contortus.*

(*d*) *Fluke Diseases of Cattle.*—Studies on these diseases were commenced during the year and have been confined to the stomach flukes, *Paramphistomum* spp. Information is being accumulated on their distribution and economic importance. Two, and possibly three species are recognized. A technique for the examination of cattle faeces for fluke eggs has been developed—this depends on the high specific gravity of a mercuric iodide-potassium iodide solution. In connexion with the investigation of the life histories of these flukes throughout the spring and summer, some thousands of snails of *Bullinus pectorasa, B. brisbanica, Lymnea strangei,* and *Planorbis* spp. were collected from known widely scattered fluke areas and examined in the laboratory without discovering the intermediate form of the fluke. Attempts to infect these snails in the laboratory were also unsuccessful. It was not until April, 1949, that the forms were discovered in snails of *Planorbis* spp. from a locality below Mount Lindsay, New South Wales. Since then the forms have been found in snails of this species from other areas, and in some cases the infection rate has been as high as 16 per cent.

4. CATTLE TICK.

(*a*) *Bio-assay Tests.*—A method has been developed to make preliminary determinations of the relative toxicity of promising acaricides to both adult female and laval ticks. The toxicity of DDT to larval ticks was found to vary considerably depending upon the formulation, a colloidal suspension containing one part of the active principle in 7,000,000 being as effective as an alcoholic solution containing one part in 30,000. The colloidal suspension of DDT was more toxic to tick larvae than any other acaricide so far tested, whereas "Parathion" (E.605), one of the more recently developed synthetic materials, appears to be more effective against adult ticks. Until more information is available on the residual toxic effect of these substances to ticks, no conclusion can be drawn as to their relative value in control.

In considering the practicability of eradicating cattle ticks by means of acaricides, it is necessary to discover whether mature female ticks are capable of depositing viable eggs after treatment. The bio-assay method has shown that DDT is less effective in inhibiting the production of viable eggs than several other insecticides. At least half of the mature female ticks subjected to a concentration of DDT, similar to that being used at present in dipping vats, deposit viable eggs.

(*b*) *Biological and Ecological Investigations.*—Additional useful information on the non-parasitic life cycle of the cattle tick and the factors influencing survival of larval ticks in the field has been obtained. Under laboratory conditions, the length of the preoviposition period, the number of eggs produced, the incubation period, and the time during which eggs are deposited, appeared to be governed by temperature rather than by relative humidity. On the other hand, relative humidity is probably the major factor affecting the viability of eggs and longevity of larvae. The optimum humidity for egg incubation and larval survival is about 90 per cent. The importance of ticks remaining on cattle during the winter should not be underestimated in any plan to eradicate this pest. Oviposition by mature female ticks can be halted and recommenced merely by variations in temperature and there appears to be little doubt, therefore, that a few eggs can be deposited at irregular intervals during the winter.

Observations have been made in the field to determine the length of the preoviposition period, the number of eggs produced, and the percentage which hatched at various times of the year. Larval activity, assessed by regularly sampling larvae on cattle, commenced about the end of September and reached a peak at the end of January, with a subsequent lesser peak at the end of February. Upward trends in larval populations were followed 21 to 28 days later by similar trends in populations of medium-sized adult ticks.

From laboratory observations on the effect of various humidities on tick larvae, it is clear that larval mortality in the field must be very high at relative humidities less than 90 per cent. Under field conditions, the length of larval life was greatest between November and February when it ranged from one to fourteen weeks, with a mean of six weeks. However, since larval ticks in laboratory cultures remain alive for as much as 27 weeks, conditions normally prevailing in the field must have an important effect in limiting larval survival.

In the field, tick larvae show three characteristic tendencies, to ascend vertical objects, to migrate towards a diffuse light source, and to congregate in groups. After seven days, some 99 per cent. of 25,000 ticks released had not migrated more than 15 inches from their point of release.

(*c*) *Pasture Spraying.*—Treatment of a tick-infested pasture with DDT in the form of a colloidal suspension containing 0.1 per cent. of the active ingredient, gave practically complete control of larval ticks for a period of six to eight days after treatment. Thereafter, the larval population gradually increased until, by the twenty-seventh day after treatment, it had greatly exceeded the original density. In this test, 1.147 lb. of *pp'*–DDT was applied per acre by means of a power spraying plant.

(*d*) *Analyses of Dipping Fluids.*—It is unfortunate, from an analytical viewpoint, that both DDT and BHC, the acaricides which have featured so largely in recent experiments, exist in isomeric forms which are difficult to analyse. It is rarely possible to determine, by purely chemical methods, the amount of any one isomer present in a mixture because of their almost identical chemical reactions. Much attention has, therefore, been given to refining methods of analyses of acaricidal fluids. A polarographic method has now been developed and progress has been made in standardizing this for use in the routine analyses of dipping fluids.

(*e*) *Bacterial Oxidation of Arsenical Cattle-dipping Fluids.*—The study of the enzymic mechanism of arsenite oxidation by the Pseudomonads isolated from "oxidized" dipping fluids has been continued. The participation of an adaptive specific arsenite dehydrogenase system has been demonstrated in cell-free preparations and oxidation models have been successfully constructed from this preparation and suitable autoxidizable electron acceptors. From the previous demonstration of the essential role of the cytochrome oxidase system and from a knowledge of redox potentials, it is reasonably certain that during bacterial oxidation of arsenite the pair of electrons transferred from arsenite by the arsenite dehydrogenase system is passed on to cytochrome *c* or *a*, thence through cytochrome oxidase to atmospheric oxygen. The nature of the intermediate electron-transporting carrier, if any, between the dehydrogenase and cytochrome has not yet been determined. The knowledge gained from inhibition studies last year has been applied in an attempt to prevent bacterial oxidation in small-scale model dips with faecal contamination. It was found that very small amounts of potassium cyanide (65 parts per 1,000,000) completely arrested during the course of the observations (six weeks) further oxidation in a "dip" already oxidized to the extent of 29 per cent., whereas in the same period sufficient oxygen had dissolved through a 5.5 mm. layer of liquid paraffin to permit oxidation to reach 45 per cent., and in the untreated dip it had reached 82 per cent. The amount of cyanide (1½ lb.) necessary for a dip of 2,500 gallons would cost 11s. 3d.; its concentration would be too small to harm man or stock, and would be of less toxicological significance than the arsenic in the dip; but unlike lactose or the considerably cheaper molasses, its use is not followed by reduction of the already oxidized arsenic and hence would be preferred only in special circumstances. An organic mercurial, phenyl mercuric nitrate, was also completely effective in arresting oxidation in a concentration of 71 p.p.m. but its high cost (£5 10s. per lb.) makes its use prohibitive.

(*f*) *Effect of Long-continued Cutaneous Application of DDT Oily Solutions to Cattle.*—This experiment is being concluded by slaughter of the animals concerned. To date, abnormalities have not been detected either clinically or after autopsy. Specimens are being collected for eventual determination of DDT storage.

5. DEVELOPMENT OF HYBRID DAIRY CATTLE.

The experimental herd at the F. D. McMaster Field Station has increased to 59 head, made up of 22 head of British breeds of dairy cattle and 37 which have Zebu "blood".

Two one-quarter Zebu-bred Jersey heifers under Government herd test, beginning as junior two-year-olds, gave 214 and 210 lb. of butter-fat in 273 days. Their lactations were characterized by high persistency, high butter-fat content, and relatively low milk yield. Use of the customary correction factor indicates 280 lb. of butter fat to be their approximate mature equivalent production. The maternal instincts of these two heifers at either their first or second calving were not pronounced, but their general behaviour was entirely satisfactory for dairy cattle. Generally, Zebu-cross calves fed from a bucket and reared on the Field Station are at least as docile and tractable as the most docile of standard-bred dairy cattle.

Body temperatures and respiratory rates of animals in the herd are taken regularly. The observed body temperatures disclose that the heat-regulating mechanisms of all the cattle, irrespective of age or breed, were quite efficient over the range of atmospheric temperatures experienced. It has also been observed that the respiratory rate of a pure Zebu female is approximately half that of British-bred females at all observed temperatures. Furthermore, observation of hybrid animals with varying percentages of Zebu suggest that respiratory rates decrease with increasing percentages of Zebu "blood". At atmospheric temperatures in the order of 85° F., although their body temperatures remained apparently normal and the animals showed no signs of distress, the respiratory rate of all the observed animals increased markedly. When atmospheric temperatures were 85° to 89° F., the rate of British-bred dairy cattle increased by 77 per cent., whereas the rates of the pure-bred and three-quarter-bred Zebu increased by 56 and 59 per cent. respectively. Even at this increased rate neither of the animals with high concentrations of Zebu reached the mean rate of all British-bred animals observed at between 65° and 69° F.

6. INVESTIGATION OF BEEF PRODUCTION IN AUSTRALIA.

The survey of beef production in Australia has been continued. During the first portion of the year field work was carried out in the Northern Territory and the data recorded. Field work was re-commenced in April, 1949, in the northern districts of New South Wales.

Experimental work with beef cattle requires a system of carcass appraisal to give accurate measurements on the end product. During the year an officer has been working at the Cannon Hill (Queensland) Abattoir on this problem, and has developed a system which has given satisfactory results on the carcasses examined to date. It is now being subjected to further tests over a wider range of carcasses derived from cattle of various breeding and age groups.

7. BEEF-CATTLE FEEDING INVESTIGATIONS.

With funds provided by the Australian Meat Board, and facilities kindly made available by Mr. G. H. Hooper, of "Talbingo", Tumut, New South Wales, studies are being made on seasonal changes in body weight from weaning to maturity, and on problems of stall-feeding beef cattle for "topping off" purposes. The observations include the dietary levels of concentrate and roughage most suitable for fattening purposes, the rate at which steers can be brought to full feed in the fattening stalls, and the incidence of digestive disturbances associated with the fattening period. It is proposed to continue this work for a period of three years.

IX. ENTOMOLOGY.

1. GENERAL.

Throughout the world insects are responsible for enormous losses to primary production, and Australia on the whole probably suffers more than her fair share of these losses. Work to control these insect pests is of great importance, as is the allied work of using insects against plant pests.

The Organization's work in this field is undertaken mainly by its Division of Entomology with headquarters at Canberra, although some work on timber pests is carried on in its Division of Forest Products (*see* Chapter XII., Section 7 (*a*) and (*c*)), and work in the field of veterinary entomology in its Division of Animal Health and Production (*see* Chapter V., Sections 3 and 4).

Division of Entomology.—The work of this Division during the past year is outlined in the remainder of this Chapter.

Progress has been made in most fields of research which have engaged the attention of officers of this Division during the year. Chemical methods, which offer a rapid and useful means of reducing the injury caused by insects, have been further examined with special reference to the part that DDT has played and is likely to play in this field. Experimental work has continued to justify the tentative conclusion reached last year that DDT, applied to subterranean clover pastures, is of special worth in the control of the red-legged earthmite. An economical method of applying this material, mixed with the superphosphate fertilizer normally spread annually on improved pastures by the more progressive landholders, has been developed.

Several problems associated with the use of DDT and BHC against cattle tick were investigated. A preliminary evaluation of some of the more recently developed insecticides was made, keeping in mind the need for a material with residual qualities comparable with DDT, and with rapid initial "knock-down" properties, yet one which would be non-toxic to higher animals.

A field station was recently established at Bright, Victoria, where a team of investigators is closely following the progress of the chrysomelid beetles introduced for the control of St. John's wort. Evidence has been adduced that several other exotic insects, liberated in Australia by this Division in an endeavour to control insect pests, have become established and are likely to be of considerable assistance in primary production. The study of the more fundamental aspects of insect control has also progressed.

Early in the year, the Chief of the Division visited Europe as an Australian representative to the Fifth Commonwealth Entomological Conference, held in London, and the Eighth International Congress on Entomology, held in Stockholm.

2. CATTLE TICK.

Work in this field is reported in detail in Chapter VIII., Section 4. The various aspects to which attention has been given are outlined below.

(*a*) *Bio-assay Tests.*—A method has been developed for making preliminary determinations of the relative toxicity of promising acaricides to both adult female and larval ticks. The toxicity of DDT has been examined using this technique.

(*b*) *Biological and Ecological Investigations.*—Additional useful information on the non-parasitic life cycle of the cattle tick and the factors influencing survival of larval ticks in the field has been obtained.

(*c*) *Pasture Spraying.*—Control of larval ticks using DDT sprays has been examined.

(*d*) *Analysis of Dipping Fluids.*—Methods of analyses of acaricidal fluids have been examined.

(*e*) *Toxicity of DDT to Cattle.*—The toxicity trial of DDT in oil against cattle has been terminated.

3. SHEEP BLOWFLY.

(*a*) *Insecticides for Protection against Body Strike.*—Tests were continued on the effectiveness of applying insecticides to the tip of the fleece as a protection against body strike. This work is reported in detail in Chapter VII., Section 18 (*a*).

(*b*) *Taxonomic Status of the Australian Sheep Blowfly.*—Doubt has recently been cast by overseas workers on the validity of the separation of flies of the genus *Lucilia* attacking living sheep in Australia into two species, *L. cuprina* and *L. sericata.* This position is, therefore, being re-examined. It has been found that adults of the two species can be separated readily by at least five characters and have different habitat preferences, but it has been very difficult to obtain laboratory crosses between them. These factors, together with the frequent records in strike wounds of *L. cuprina* and the rare presence of *L. sericata,* make it clear that the two species are distinct.

4. SANDFLIES.

Overseas reports have indicated that a very satisfactory measure of control of sandfly larvae has been obtained by applying DDT to the streams in which the larvae develop. A preliminary test of this nature was carried out in a stream infested with larvae of the sandflies *Simulium ornatipes* and *S. calthrinum* near Brisbane, Queensland, using a calculated concentration of *pp'*–DDT of 0.9 parts per 10,000,000. Subsequent examinations revealed that larvae had disappeared for a distance of 50 yards downstream from the application site within 24 hours of treatment, and this region remained free of larvae for a period of fourteen days.

5. INSECT PHYSIOLOGY AND TOXICOLOGY.

Work has progressed during the year on a number of aspects of insect physiology which it is hoped will ultimately lead to a better understanding of vital processes which are susceptible to interference by selective insecticides. Aspects investigated, which are not dealt with in more detail below, include studies on the polyphenols and proteins responsible for the hardening and darkening of insect cuticle, on the cuticular lipoids which are so important in conferring impermeability to water and water-soluble materials, on the reasons for the possession of alkaline digestive juices in larvae and adult Lepidoptera, and on the peritrophic membrane which protects the midgut cells of many insects from damage by hard particles of food. In addition, a chapter on insect digestion was prepared for a text-book of insect physiology soon to appear.

(*a*) *Digestion of Wool-eating Insects.*—With the background gained in a study of the digestive processes of the cockroach *Blattella* which was reported last year, work has been commenced on the physiology of digestion of the larva of the clothes moth *Tineola.* It has been shown that *Tineola* can digest wool keratin in which all sulphur is in the form of disulphide linkages. Sulphydryl groups can be detected first in the midgut about one-third from the anterior end. It can be shown that a dehydrogenase is active in this same region, and a marked difference in the histological structure of the midgut epithelium is also evident at this point. Certain other insects examined (*Blattella,* larvae of *Pieris rapae*) will ingest wool fibres cut into 100-micron lengths, which is the length into which *Tineola* larvae cut the fibres before ingesting them. But fibres so ingested undergo no substantial digestion, indicating that there are differences between the digestive processes of *Tineola* larvae and the other insects. This work is being continued in an endeavour to discover whether the differences lie in the digestive enzymes themselves, in the reducing power of the gut, or in some other factor.

(*b*) *Mothproofing Tests.*—The method of testing the resistance of fabrics to clothes moth attack is being studied in an attempt to obtain uniformity between tests. Inbreeding of the test insects is being undertaken, and the fourth generation of brother-sister matings is now being established.

(*c*) *Insect Muscle Respiration.*—Further purification of adenyl pyrophosphatase from insect muscle has yielded preparations with activities at least twice as great as those previously obtained. In the migratory locust, it has been found that the activity of the enzyme per unit weight of protein is about three times as high in wing muscle as in leg muscle. The enzymatic activities of myosins extracted from wing and leg muscles, however, were about the same.

While testing the inhibition of insect muscle enzymes, it was found that ninhydrin inhibited also rabbit myosin-ATP-ase and that this inhibition was reversed by cysteine. At the same time the ability of myosin to combine with actin to form the highly viscous, fibrous colloid, actomyosin, the main mechanical component of muscle, was unaffected. This discovery throws doubt on the previously-held belief that the combination of myosin with both ATP and actin is dependent on the same -SH groups.

Some preliminary work on the chemistry of adenyl polyphosphate isolated from insect muscle was also undertaken.

(*d*) *Excretion in Blowfly Larvae.*—The striking accumulation of granules in a specialized region of the excretory malpighian tubules of blowfly larvae was investigated. The granules have been shown to be simply waste products formed as a result of the specialized nature of the cells in the accumulating region and stored there by virtue of the absence of peristalsis and of adequate flushing of water down the tubules. They do not appear to be involved in any physiological process essential to the larvae, their composition and amount depending directly upon the calcium, magnesium, and phosphate contents of the food. A number of other features of excretion in blowfly larvae were also examined.

(*e*) *The Occurrence of Mucus in Insects.*—Arising out of the earlier work on *Blattella,* the distribution of mucoid substances in insect tissues has been investigated. It has been shown that they are much less widely distributed than in vertebrates, only the salivary glands regularly containing any considerable amount of material with the properties of a mucoprotein.

(*f*) *Evaluation of Insecticides.*—The individual dosage method for obtaining toxicological data on insecticides, involving the application of measured dosages of insecticides to individual houseflies, has given satisfactory and reproducible results with DDT, gamma-BHC, chlordane, and pyrethrum. It shows promise of becoming a convenient standard procedure for the biological evaluation of insecticides. An Australian sample of a chlorinated hydrocarbon similar to chlordane proved, when evaluated in this way, less than one-tenth as toxic as chlordane.

In comparative tests against potato moth larvae with pyrophyllite dusts containing 1 per cent. of some of the newer insecticides, 0,0-diethyl 0,*p*-nitrophenyl thiophosphate (E.605) and 2,2-bis (*p*-anisyl)-1,1,1-trichlorethane (methoxychlor) were slightly faster, and chlorinated camphene slightly less effective than DDT in insecticidal action.

Dusts prepared from the seeds of nineteen strains of *Pachyrrhizus erosus* and one of *P. strigosus* (yam beans) grown in Australia were evaluated for insecticidal properties. They were slow in insecticidal action and low in toxicity, *P. strigosus* being more effective than *P. erosus.*

6. Biological Control.

(*a*) *St. John's Wort.*—In view of the apparent progress being made by the introduced Chrysomelid beetles, *Chrysomela hyperici* and *C. gemellata,* in the control of St. John's wort, it seemed necessary to initiate an intensive field study of the fluctuations in the beetle population in relation to the host-weed density. By quantitative methods the value of the beetles can be assessed more accurately and the plant succession following the destruction of weed stands can be traced. These ecological studies commenced during the year in the upper part of the Ovens Valley in Victoria and in the Mannus Valley in New South Wales.

During 1948 a total area of between 150 and 200 acres of medium to dense stands of St. John's wort in the parishes of Bright, Freeburgh, and Porepunkah was defoliated completely by the beetles. However, the total area in which the weed mortality was high did not exceed 30 acres. At Mannus, where the beetles have made less progress, the area of dense wort killed amounted to only a few square chains. High mortalities of the weed were recorded only where the plants were kept defoliated from the beginning of September (or before) until early December, that is, where the plants were heavily and almost continuously attacked, first by larvae and then by adults, for at least three months. Wort attacked in this way for the first time was killed just as readily as wort attacked heavily, but not fatally, in previous years. Few plants died in weed stands which were defoliated by adults only.

It was found that wort plants differ markedly in their susceptibility to beetle attack. Susceptibility appears to be related to the age of individual crowns, old crowns being much more easily killed than young, and habitat may play a part in determining the susceptibility of a stand. In some dense infestations of the weed, complete defoliation of the flowering shoots by adults stimulated suckering and, therefore, an increase in the proportion of young crowns. It is thought possible that the resulting stands may be more resistant to beetle attack than the original ones.

In some areas of the Ovens Valley, totalling several hundred acres, regeneration of the wort has been negligible after killing of the original plants by the beetles. However, the failure of the weed to re-establish itself cannot be attributed to the activities of the beetles. Elsewhere, seedlings increased in size and density during 1948 where beetles had killed out the original infestations, in several instances in spite of complete defoliation during the winter by beetle larvae. Though no evidence has been obtained to show that the beetles can prevent the redevelopment of dense wort stands, much remains to be done before final conclusions are reached.

Unfavorable weather conditions and exhaustion of the available food supply by the beetles themselves are factors of importance in the reduction of beetle numbers. Predators have not prevented their rapid increase up to the present time.

Surveys designed to provide a better understanding of the incidence of St. John's Wort and the possibility of beetle establishment in New South Wales, Victoria, and South Australia have been continued. More than 1,750,000 beetles were liberated in the three States during the year. Those established in Western Australia the previous year have made satisfactory progress.

(*b*) *Control of Lantana on Norfolk Island.*—During this year a consignment of *Teleonemia lantanae,* the lantana bug, was sent from Brisbane to Norfolk Island. Liberations made some years ago failed to establish the insect, but considerable success has attended this latest attempt. The bugs have survived one winter and have had a considerable effect upon the weed.

(*c*) *Potato Moth.*—During the past season further liberations of the parasites *Copidosoma kochleri, Chelonus phthorimaeae,* and *Microbracon gelechiae,* were made in most States. It now seems that sufficient numbers of these parasites have been liberated for their establishment, if this is possible. It is intended, therefore, to restrict or cease further breeding and liberation work, and to attempt to recover the parasites in the field and determine whether or not they are established.

(*d*) *Cabbage Moth.*—Considerable progress has been made in the attempt to introduce the two Icheumonid parasites *Angitia cerophaga* and *Diadromus collaris,* despite some difficulties experienced in breeding *Diadromus.* Of *Angitia,* 68 consignments totalling 133,000 parasites were despatched to the different States for liberation by State entomologists. Recoveries of *Angitia* have been made in Tasmania, New South Wales, Australian Capital Territory, and Queensland, but no information is available concerning the other States. It seems likely that this parasite is well established. Of *Diadromus,* 39 consignments, totalling some 8,500 individuals, were sent for liberation to the different States, and recoveries have been made in Tasmania and the Australian Capital Territory.

With both of these parasites a recovery survey is to be undertaken. It is not intended to breed or liberate *A. cerophaga* in large numbers in future as this now seems unnecessary. More attention will consequently be given to *D. collaris,* the breeding of which has not proved easy.

A population study has been made in the field of *Plutella,* these two parasites, and the many other primary and secondary parasites occurring in this insect complex. Both *Angitia* and *Diadromus* increased rapidly when liberated in the area sampled.

(*e*) *Cabbage Butterfly.*—A detailed study has been made in the Canberra area of the effect of *Apanteles glomeratus* and *Pteromalus puparum* upon the cabbage butterfly, *Pieris rapae.* It has been shown that the parasites have a considerable effect on the butterfly population and that their introduction has proved most valuable. The effectiveness of *A. glomeratus* unfortunately is undermined by a secondary parasite. No primary parasites, apart from these introduced species, attack *Pieris* in this area. Two consignments of *Apanteles glomeratus* were sent to Tasmania, where this larval parasite of cabbage butterfly has not previously been liberated.

Plans are now under way for the introduction in the coming season of *A. rubecula,* an important enemy of *P. rapae* in Europe, that was not established in Australia when liberations were made a few years ago.

(*f*) *Green Vegetable Bug.*—Supplies of *Microphanurus basalis,* the egg parasite of the green vegetable bug, *Nezara viridula,* were obtained in New South Wales and despatched to New Zealand where *Nezara* has recently become a pest.

Plans have been made for the introduction of the Tachinid parasite of *Nezara, Trichopoda pennipes,* from the United States in the coming season. Earlier attempts to establish this parasite were abortive.

(*g*) *Citrus Red Scale.*—Further consignments of *Comperiella bifasciata* were imported from California through the agency of the Commonwealth Bureau of Biological Control, after discovering that this parasite promised to be effective against red scale, *Aonidiella aurantii,* in California. From 19 consignments received, about 12,000 parasitized scales were despatched for liberation to Queensland, Victoria, and Western Australia. No information is available concerning the establishment of *Comperiella* from these liberations.

7. Population Dynamics.

Using *Lucilia cuprina* in the experiments, the indications obtained last year that muscoid flies kept in a constant environment and supplied with food at a constant rate should oscillate in density, were confirmed. It was found that the oscillations are extremely violent and show no sign of diminishing with time. Examination of the underlying mechanism of oscillation showed that it was entirely due to the delayed effects of severe competition for food amongst the larvae, for the adults, which had access to the same meat, always consumed ample food to develop their eggs.

In another set of experiments, the adult flies were given protein food at a constant low rate, while the larvae were provided with separate food in excess. It was found that similarly violent oscillations in density were produced, but were due to the delayed effects of adult competition: there was a great reduction in the number of eggs laid at high densities, instead of a great destruction of larvae by starvation.

In other experiments, the adult life was shortened by reducing the amount of sugar supplied to the adults, or by withholding it altogether. Violent oscillations in density were still produced, but were of much shorter period.

In experiments in which the same meat was available to both larvae and adults, it was found that the constant destruction of 50 per cent. of the pupae produced lowered the average number of flies to about half; whereas the destruction of 50 per cent. of the young larvae more than doubled the number of adults produced when there was no such destruction. This result is of outstanding importance for it indicates that the continued destruction of a high percentage of a pest can increase the average abundance of the pest under certain circumstances.

8. Locusts and Grasshoppers.

During the closing months of 1948, isolated small bands of *Chortoicetes* nymphs developed in the Bogan-Macquarie Area, and were kept under observation from the Trangie field station. The bands were later heavily attacked by birds, particularly ibis, which greatly reduced their size and scattered the insects that remained, so that no adult swarms resulted.

The ecological control experiments were continued in the Trangie district. Work was mainly confined to maintenance of the tree barriers, recording the progress of growth there, and the progress of colonization of the scalds under the scald reclamation project. However, one additional species, the Athel tree (*Tamarix articulata*), was given a preliminary trial as a possible barrier component and has shown some promise.

Further studies have been made on the distribution of various species of grasshoppers by means of field surveys. One such survey in central and northern New South Wales during December, 1948, provided additional information on the range of the small plague grasshopper (*Austroicetes cruciata*) in that region, and a second collecting trip in Tasmania added to the knowledge gained from the earlier visit to that State in January, 1948.

Following the phenomenal rains and floods in the north-western corner of New South Wales and in south-western Queensland, an expedition into this region was undertaken during the late autumn to discover whether any build-up of the *Chortoicetes* population had occurred as a result of the floods. The flood-plain of Cooper's Creek between Windorah and Naccowlah Island had been suspected as an outbreak area of *Chortoicetes* and a possible source of outbreaks in South Australia, but there had been no direct evidence of swarm formation in this region. The expedition was unable to reach the Cooper itself, but a loose swarm was seen along a tributary creek some 25 miles from the ood-plain, and other definite evidence of local swarm ormation was obtained. Thus the status of this region s an outbreak area has been established.

Investigations on the taxonomy of the Australian *cridiae,* and of the phases of three swarming species, ave been continued. A detailed examination of certain spects of the phase theory of locusts has been made, as result of which modifications to the theory have been roposed in a paper now ready for publication.

Further investigations have been made into the iology of species of wolf spiders (*Lycosidae*) which rey upon locusts in the Trangie district. A study of he taxonomy of the species concerned is being made by rofessor V. V. Hickman of the University of asmania.

9. Pasture Cockchafers.

The main feature of the year's work has been the ccurate determination of the distribution of *Aphodius owitti* Hope in New South Wales. This has been chieved by the use of further questionnaires and by xtensive field surveys.

Damage to pastures by the larvae of *Aphodius* was very slight in most parts of New South Wales during 1948. This is attributed to the heavy summer and utumn rains of that year. Such data as can be gathered concerning past infestations indicate that eavy infestations do not occur following heavy rains arly in the year, and this appears to be largely due to the eggs being attacked by fungi and to the probable asphyxiation of both eggs and young larvae in waterlogged soils. Older larvae are remarkably resistant to the effects of heavy and prolonged rain.

Field investigations of the behaviour of adults and larvae have been continued. It is now known that adult behaviour is rather more complex than was originally thought. When the female is fully fed and her ovaries mature, certain physical characters of the pasture become of importance in influencing the choice of oviposition site. The female prefers to alight on bare ground and move to the edge of vegetation before burrowing down. Pastures that are hard-grazed, or in poor condition for other reasons, and in which the sward is not uniform but broken by small patches of bare soil, are preferred for oviposition. It has been found that well-defined patches of infestation are not necessarily the result of mass settlings of ovipositing beetles, but may be due to the gradual accumulation of eggs throughout the flight period of several months. This indicates the inherent attraction of the oviposition sites, and suggests the possibility of recognizing them and treating them with insecticides before severe damage can be done.

Direct observations of larval behaviour were made for the first time during the period under review. Migration occurs only when rain is actually falling, or while the soil surface is still wet. Between falls of rain, damage is confined to the vegetation in very close proximity to the burrow, and the total damage, as well as the rate of development of the larvae, is roughly related to the distribution of autumn and winter rains. Although the soil thrown up in making burrows is produced largely, if not entirely, by simple excavation, a certain amount of soil is passed through the gut, and there are indications that in soils rich in organic matter, development is considerably more rapid than would be expected from the quality and quantity of vegetation available on the surface. Under laboratory conditions, larvae have made excellent development in the complete absence of both vegetation and dung, if supplied with organic matter such as leaf mould.

Studies of the distribution and bionomics of other cockchafers have continued, with particular reference to *Sericesthis pruinosa, Adoryphorus couloni,* and *Liparetrus obtusidens.* The first two species damage pastures and lawns in the larval stage, while the last defoliates eucalypts in the adult stage.

Larval-adult correlations have been established for some 25 species by rearing the larvae, many of which have been described and figured.

With regard to the insecticidal control of *Aphodius howitti,* the plots that received 3.3 lb. of DDT (pp′ isomer) per acre in August, 1946, still show a residual effect of the insecticide, although they are no longer completely free of infestation as reported last year.

10. Red-legged Earthmite.

In examining the practicability of direct methods of control of pasture pests with insecticides, the cost involved is a most important consideration. The fact that DDT dust is capable of reducing earthmite populations in legume pastures to a negligible level having already been demonstrated, attention during the past year has been devoted to determining the minimum concentration of DDT necessary and the most economical method for its application.

It has been shown that DDT can be applied effectively when mixed with the superphosphate fertilizer which is usually spread on subterranean clover pastures during the late summer before the autumn rains provide conditions favorable for the hatching of aestivating earthmite eggs. Experiments have also confirmed the previous evidence that DDT applied to the soil has a residual effect on earthmites over a considerable period. A DDT-superphosphate mixture containing 2 per cent. of the toxic ingredient and applied at the rate of 2 cwt. per acre in 1946, practically eliminated the earthmite population in a subterranean clover pasture and has since maintained it at a very low level. This treatment has considerably increased the yield of clover.

A pasture treated with a similar DDT-fertilizer mixture at 1 cwt. per acre yielded less subterranean clover per acre, although the reduction in the earthmite population was comparable with that in a pasture which received this mixture at twice the rate. Yields of clover during the first year following treatment with a DDT-superphosphate mixture containing 0.5 per cent. of the toxicant were similar to those following treatment at twice the DDT concentration. Yield figures during the second year will be followed with interest. Mite populations in the former pasture were much greater than in the pasture treated with the higher concentration of DDT, but were still only one-fifth as great as those in untreated pasture. Mixtures containing 0.1 and 0.25 per cent. DDT were less effective in controlling earthmites and yielded considerably less clover. Observations suggest that pastures treated with superphosphate and DDT at the higher concentrations not only yielded a greater bulk of feed but also were more palatable to grazing stock.

Alternative methods of controlling earthmites in subterranean clover pastures have also been examined. The effect upon earthmite populations and subsequent yields of a light rapid burning and an intense slow burning of an infested pasture has demonstrated that there was a substantial reduction in the numbers of earthmites, associated with a subsequent threefold increase in the clover yield, when the burning was intense and slow. The more superficial burning was ineffective.

11. Insect Vectors of Plant Viruses.

(*a*) *Tobacco Yellow Leaf Dwarf.*—This disease was known to be transmitted in the field by the common brown jassid, *Orosius argentatus,* and the biology and ecology of the insect in northern Victoria had already been studied. Recent experiments have shown that the brown jassid is able to acquire sufficient quantities of the virus to become infective after a feeding period of one minute on a diseased plant and that infective insects are able to transmit the virus to healthy plants in five minutes. Transmission experiments in the glasshouse have shown that the disease can be experimentally transmitted by the jassid to at least fifteen host plants, including weeds common in tobacco-growing districts, pasture plants, and ornamentals commonly grown in the home garden. All of these plants were symptomless carriers.

(*b*) *Witches' Broom of Lucerne.*—This disease is prevalent throughout the inland areas of Queensland, New South Wales, Victoria, and South Australia and has been reported from north Western Australia. Transmission of the disease has been effected by grafting, although all previous attempts at transmitting it by insects have been unsuccessful.

A survey of lucerne fields where the disease is prevalent at eight stations along the River Lachlan, New South Wales, has been in progress for one year, particular attention being given to a study of insects belonging to the family Jassidae (Cicadellidae). Ten species of jassids were found to occur at all stations and at Dickson Experiment Farm, Australian Capital Territory, where a study of the seasonal abundance of these species has been made from weekly collections.

During the year, the disease was successfully transmitted by one of these insects, the common brown jassid, *O. argentatus,* from lucerne to a number of other host species and this jassid is recorded for the first time as a vector of the disease. Transmission experiments to transfer the disease back to lucerne are still in progress. Infected plants consistently produce a virescence of the floral parts strikingly similar to that caused by tomato big bud (virescence) on its host plants. It is suggested that the two diseases may be strains of the one "yellow" virus.

12. TERMITES.

Laboratory testing to determine the resistance to termites of a large number of treated and untreated materials, using standardized colonies of *Coptotermes lacteus* and *Eutermes exitiosus,* has been an important feature of the termite research. Five hundred and twenty-two test colonies of *E. exitiosus,* and 212 of *C. lacteus* have been installed. Materials studied in these tests have included both native and overseas commercial timbers, building boards, cotton furnishing felts, bookbinders' linen, and various anti-termitic materials. Once again the results have shown that pentachlorphenol is a highly effective anti-termitic material.

Most of the laboratory testing programme, however, was devoted to an investigation of the comparative resistance of five native commercial hardwoods. The results have shown that the order of decreasing resistance to *E. exitiosus* is: *Tristania conferta, Eucalyptus acmenioides, E. microcorys, E. maculata, E. pilularis.*

The field testing of timbers and preservative materials has continued and a report on the condition of samples in the International Termite Exposure Test was prepared and forwarded to the sponsors of the project in Madison, United States of America. (*See* also work in the Division of Forest Products, Chapter XII., Section 7 (*a*).)

The first examination of the soil poisoning tests showed that both creosote and 5 per cent. pentachlorphenol (both used at the rate of 0.5 gall./cu.ft. soil) had given complete protection for twelve months, whereas lead arsenate and white arsenic (both used at the rate of 2 oz./cu.ft.) had both failed. Additional tests were installed using 5 per cent. sodium pentachlorphenate and 10 per cent. sodium arsenite (both at 0.5 gall./cu.ft.).

Approximately 100 series of termites have been received for identification during the past year, including several series from Malaya.

13. MISCELLANEOUS PESTS.

(*a*) *Mites.*—Prior to the recent discovery of the acaricidal properties of the organic phosphate insecticides, mites of the species *Tetranychus urticae* and *Bryobia praetiosa* could not be adequately controlled by chemical means, and in many instances the use of DDT codling moth sprays in apple orchards indirectly brought about increases in the numbers of these mites. An investigation was therefore made of the acaricidal properties of the new organic phosphate insecticide 0,0-diethyl 0,*p*-nitrophenyl thiophosphate (E.605).

(i) *Glasshouse Tests.*—E.605 gave excellent results against *Tetranychus urticae* infesting glasshouse plants in Canberra. An emulsion applied as a finely atomized space spray at the rate of 0.45 g. of E.605 per 1,000 cubic feet completely eradicated mites from a 4,500-cubic feet compartment of the glasshouse. All active stages of the mite were killed by a single treatment, but since the spray had no ovicidal effect, a second application was necessary after all eggs had hatched but before the resulting mites reached maturity. At 0.35 g. per 1,000 cubic feet the kill was incomplete but very high. Other glasshouse pests including aphids, cockroaches, and flies were also killed. The E.605 sprays caused no injury to a wide variety of plants.

(ii) *Orchard Tests.*—Experimental spraying of apple trees in a Canberra orchard showed that four applications of an 0.01 per cent. E.605 spray, commencing on 19th November and applied at three to four week intervals, gave satisfactory control of *Tetranychus urticae* throughout the season. The complete ineffectiveness of 0.1 per cent. DDT sprays against mites was confirmed. In mid-summer severe infestations of mites on the DDT-sprayed trees were effectively reduced by an application of 0.02 per cent. of E.605.

(*b*) *Meat Ants.*—Experiments to determine the practicability of eradicating meat ants (*Iridomyrmex detectus* Sm.) from the city and suburbs of Canberra have been continued. Work during the last two years has shown that, although applications of dusts containing either 2 per cent. DDT or 0.5 per cent. gamma-BHC destroyed the insects in the treated mounds, they did not prevent subsequent re-occupation of the nesting sites by ants which were absent from the mounds at the time of treatment. Two treatments at an interval of one week were effective in completely eliminating colonies, the first having destroyed the main population and the second the small colonies organized by the remaining ants. Applications of the dusts during March and April, before the ants commence hibernation for the winter months, have been more successful than treatments at other periods of the year. A detailed study of 2,500 nests in six Canberra suburbs has been made.

(*c*) *Argentine Ant.*—A summary of information on the occurrence and on methods of location and eradication of the Argentine ant was prepared and circulated to all State Departments of Agriculture. Notes and suggestions for an improved bait for use against this pest were also included.

(*d*) *Timber Borer.*—As part of a co-ordinated plan of research embracing the Division of Forest Products (*see* Chapter XII., Section 7 (*c*)), and the State Forest Services of New South Wales and Queensland, investigations are being conducted on various aspects of the biology of *Lyctus brunneus.* Data have been obtained on the depth at which eggs are laid, the number laid and the incubation period, the length of the developmental period from egg to adult, and the duration of adult life. Studies of the effect of different combinations of temperature and relative humidity on the rate of development are in progress.

The most suitable timbers for maintaining laboratory cultures of *L. brunneus* have been *Sterculia acerifolia, Alstonia scholaris,* and *Schizomeria ovata.*

14. Taxonomy.

Steady progress has been shown in the taxonomic revision of certain of the more important groups of insects. The Tachinidae, a large family of useful parasitic flies which has received little attention in the past, is being actively studied and the divisional collection is being substantially improved by the addition of material collected in the field. The revision of the Australian ants by a specialist working in Melbourne on a Commonwealth Scientific and Industrial Research Organization grant has continued satisfactorily. During the year, an officer of the British Museum has been studying certain groups of injurious cockchafers in Australia and the knowledge so gained will be of considerable value to the cockchafer investigations being conducted by this Division.

In addition, revisions of the Australian locusts and grasshoppers by a United States specialist, and of the Australian Chalcidoid wasps by a Commonwealth Scientific and Industrial Research Organization officer, are proceeding. Considerable stress is being placed upon life-history studies of the parasitic wasps.

Many important moths, which, in the larval stages, are responsible for considerable economic damage to field and orchard crops, belong to several families well represented in Australia. The smaller species have been very inadequately studied. The acquisition of the valuable collection of the late A. J. Turner, supplemented by smaller accessions and field collections, has enabled an officer of the Commonwealth Scientific and Industrial Research Organization to undertake the revision of several of these important families. At present the Tortricidae, which include some 300 small leaf-rolling species, are being studied.

A large number of identifications have been made for institutions and individual entomologists both in Australia and overseas.

X. FISHERIES.

1. General.

The exploitation of Australia's marine resources has proceeded slowly, one of the main reasons being lack of knowledge regarding the location of fishing grounds, the migrations and other habits of fish, and suitable methods of catching different varieties under the conditions prevailing in Australian waters.

The Organization through its Division of Fisheries aims to obtain this information. It is also undertaking within its Division of Food Preservation and Transport work on fish preservation (*see* Chapter XI., Section 6).

Division of Fisheries.—The work of this Division during the year is outlined in the remainder of this Chapter. The Division has extended its activities at sea and three research vessels have been operating full-time on exploratory and general biological work. A fourth vessel was used for some three months. The Division undertook the scientific work aboard the External Territories M.V. *Fairwind* during a survey of the fish resources of the waters of the Papua-New Guinea area. One of its officers accompanied officers of the Queensland Department of Harbours and Marine, Fisheries Branch, on a survey of north Queensland fisheries resources using M.V. *Australia.*

Investigations involving the use of the Division's nets have been continued in conjunction with commercial fishermen.

A second shipment of Pacific Oysters was imported from Japan. Observations show that the oysters imported in 1947 have spawned, and that spatting has occurred.

Recently the Queensland Government handed over to the Division the living quarters of two research stations: one at Dunwich, on Stradbroke Island, now occupied by a research officer working on oyster cultivation problems in Moreton Bay; the second at Thursday Island, where the Division's programme on pearl shell cultivation has begun.

As a result of the F.R.V. *Warreen's* success in catching pilchards last year, the Albany (Western Australia) cannery has turned its attention to this fish. Commencing in a small way in May of this year and using one of the Division's lampara nets and a small purse seine, 16½ tons of this fish have already been captured and canned.

2. Operations of Research and Fishing Vessels.

(*a*) *F.R.V. Warreen.*—The F.R.V. *Warreen* continued to work in Western and South Australia. During the year cruise 31 (15th April to 11th July) was concluded and three other cruises, 32, 33, and 34 were completed.

Cruise 32 (23rd August to 25th September) covered the area from Fremantle to Point Cloates. Inshore hydrological stations, six between Fremantle and Rottnest Island and six between Geraldton and Abrolhos Island, were maintained and traverses with six stations extending 100 miles offshore were completed off Rottnest Island, Abrolhos Island, and Cape Inscription. This cruise concentrated particularly on otter trawling in the Shark Bay area in depths from 7 to 25 fathoms; Danish seine gear was also used. Tests of both types of trawl confirm the conclusions of the "Rip" that there is little possibility of a commercial trawl fishery in this area, which, however, appears to be a nursery ground for many commercial species.

Cruise 33 (4th November to 12th December) was a continuation of cruise 32 and was designed to explore the demersal possibilities of the continental shelf between Shark Bay and Fraser Island. Danish seine gear was used in depths between 40 and 80 fathoms. Though good trawling bottoms were found, hauls in the southern part of the area contained mostly flying gurnards, small flounder, saury, north-west snapper, and John Dory; in the northern part of the area little but sponges was obtained.

Cruise 34 (6th April to 7th June) had been planned to commence earlier in the year to investigate occurrences of pilchards in South Australian waters; pilchards were found but were "wild" and very difficult to catch. The coastal area between Ceduna and Port Adelaide was covered, including the islands off Port Lincoln and across the mouth of Spencer Gulf, Investigator Strait, the lower half of the Gulf of St. Vincent, and Backstairs Passage, but though shoals of small fish were seen frequently only one catch, of 3 cwt. of pilchards and anchovies, was made in Coffin Bay. Barracouta were plentiful and southern bluefin tuna were seen and caught.

(*b*) *F.R.V. Liawenee.*—During the year the F.R.V. *Liawenee* has made seven cruises. The first three were of a preparatory nature to test and check equipment; the remaining four have concentrated on the collection of material for school shark and barracouta investigations. Four hundred and sixty school sharks and 1,000 barracouta have been tagged and released at sea. Regular hydrological and plankton stations have been worked. In addition to Tasmanian waters the cruises have extended to Eden, Melbourne, and Port Fairy.

(*c*) *F.R.V. Stanley Fowler.*—The F.R.V. *Stanley Fowler* sailed from Brisbane in October and transported officers and gear to Thursday Island. Preliminary surveys and collection of hydrological data were carried out during November and the vessel returned to Brisbane late in December. A survey cruise to Lord Howe Island was commenced in March, but owing to cyclonic weather it was not extended to Norfolk Island as originally planned. The survey indicated that Australian salmon, kingfish, bonito, tuna, scad, and several species of reef fish are present in the area and that the catch taken by commercial fishermen could be considerably increased. Whilst it is not considered that large-scale exploitation of the stocks would be possible, there is little hope of even a moderate development of the industry until transport facilities to the Australian mainland are improved. At present fish fillets are flown to the Sydney market.

(*d*) *M.V. H.C. Dannevig.*—During the period of charter (7th October to 20th December) the M.V. *H.C. Dannevig* made five cruises to collect oceanographical data at stations on the coast of New South Wales and to collect material for the biological study of the species of fish taken by the east Australian trawl fishery. The area covered was from Coff's Harbour in the north to Eden in the south, and trawling was carried out on all recognized trawling grounds. At the end of November the vessel carried from Sydney to Hobart the shipment of Pacific oysters which had been imported from Japan.

(*e*) *M.V. Fairwind.*—The M.V. *Fairwind,* which is equipped with a laboratory and fishing gear, is operated by the Department of Agriculture, Stock, and Fisheries of the Papua-New Guinea Administration to survey the fishery resources of the territory. The Division has supplied research officers to undertake the scientific work of the survey. The first cruise, from Port Moresby to Tufi, was made in October and the second during December and January, from Tufi to the mouth of the Sepik, then along the south coast of New Britain, returning to Port Moresby via the Trobriand Islands. Indications are that areas such as the south coast of New Britain, the Trobriand Islands, Tami Islands, and the south-east sector of New Guinea offer good fishing possibilities. Schools of tuna were also observed.

(*f*) *Fishing Tests in Co-operation with Commercial Fishermen.*—The *Eden Star* has made a number of successful hauls with one of the Division's purse seines in the waters off the east coast of Tasmania, and approximately 72 tons of horse mackerel have been caught. The results demonstrate that mackerel could be taken in commercial quantities if the canneries were able to handle the catches and pay a reasonable price. Also in Tasmania, payable catches of sprat have been taken with a small lampara. Small regular catches of pilchards have been obtained by a crew of fishermen operating at night in Port Phillip Bay, Victoria. A lampara net was lent to them, but they preferred a small purse seine which, in conjunction with powerful electric lights, took 8 tons of fish in eight shots. The Division has lent a lampara and a fleet of eight drift nets to Australian Fishing Industries, a large commercial company operating from Eden, New South Wales. All these tests show that methods of fishing tried out and supported by the Division can be worked commercially provided a market can be found for the fish that is caught.

3. Fisheries Biology.

(*a*) *Trawlfish.*—Catch statistics show that as predicted (*C.S.I.R. Journal,* May 1948), the total catch of trawlfish has begun to decline, having receded from 16,200,000 lb. in 1946-47 to 15,100,000 lb. in 1947-48. First the morwong and later the nannygai were drawn upon to make up for the decreasing catches of flathead. With little or no decrease in the fishing effort in 1948-49 the catch per unit effort of morwong and nannygai presumably will eventually fall as that of flathead has fallen. The Danish seiners have revealed themselves as much more vulnerable than the trawlers to the effects of overfishing.

The flathead catch to-day is approximately equal to that of the other two chief trawl species; nevertheless, research on the biology of the flathead has been pushed ahead in the belief that it is fundamentally the most important species and that the stocks will recover when fishing intensity eases. Biological material on the flathead is being written up as a paper on the age-composition of the commercial catch, which will involve reference to the biological effects of overfishing.

Routine sampling of the morwong and nannygai was also pursued during the year. The spawning season of the former was established as March to early June, and of the latter as April to May.

(*b*) *Australian Salmon.*—Raciation work on the Australian salmon (*Arripis trutta*) has been intensified and extended. All the relevant evidence supports the working hypothesis put forward concerning the New South Wales and South Australian races; Tasmanian and Victorian waters contain mixed shoals of the juveniles of these races, which later divide and have widely separate spawning grounds.

In addition, samples of *Arripis trutta* from New Zealand and Lord Howe Island were determined as distinct from the New South Wales salmon, and distinct from one another. Thus the New South Wales-Gippsland (and east Tasmanian) fishery is operating on a self-contained stock.

Tag returns from 1947-48 continued to come in satisfactorily up to eleven and a half months after the date of release. They indicate migratory movement around the south-east corner of Australia, but it seems that none of the types of tags so far used reflects such movements truly. Consequently, only 200 fish were tagged during this year; they were released in south-east Tasmania.

In Western Australia, the commercial salmon catch for 1948 reached the high figure of 5,500,000 lb. When the Division made its surveys in 1943, aiming at the exploitation for canning of the hitherto little-used salmon resources, the annual catch was in the vicinity of only 40,000 to 55,000 lb. Some fishermen are beginning to fear possible exhaustion of the fishery because of the intensified fishing, but so far the accepted criteria of depletion have not been recognized.

Field work on the salmon has continued, specializing in length frequency measurements of the commercial catch at the beaches, and tagging operations.

(*c*) *School Shark.*—The programme on school shark (*Notogaleus rhinophanes*) has been expanded to include investigations by F.R.V. *Liawenee* on adult stocks of fish. Four hundred and sixty adult sharks have been tagged at sea. The tagging programme of young sharks has been increased and 800 were tagged at Pittwater, Tasmania, and Portarlington, Victoria. The 1949 tagging programme on young sharks has confirmed the work done in the two previous years in Port Phillip Bay. The two-year-old sharks, which predominate in this area, leave the Bay during the winter months. Growth rate studies on this species have been continued.

(*d*) *Tuna.*—Investigations on tuna have been conned to the routine observations made by research essels. Trolling has been done by *Warreen* and *iawenee* during their cruises in south-western and outh-eastern Australia respectively. *Warreen* has eported that the southern bluefin (*Thunnus maccoyi*) as been found to occur as far north as Dirk Hartog sland in Lat. 26°, taken in November, 1948. In the astern States, Sydney, Lat. 34°, is approximately the orthern limit for the occurrence of this species. Occurrences of large schools of tuna were observed in the egion near Point Cloates. The southern bluefin tuna eason along the New South Wales coast, which has een largely ignored by fishermen during the past ew years, appears to have been a good one.

(*e*) *Pilchards and Anchovies.*—A special cruise in South Australian waters by the F.R.V. *Warreen* yielded nformation about pilchards in that area. Biological tudies on this species have reached the stage where hey can be interrupted, and resumed when a commerial fishery has been established. The results of the biological work done on anchovies have been prepared or publication.

(*f*) *Tasmanian Whitebait.*—The total north Tasmanian catch of whitebait fell sharply in 1948. Catches n all northern rivers declined simultaneously, which confirms the earlier supposition that the stock in this area is homogeneous. Depletion of this population may now be presumed, and recommendations for regulatory action have been made to the Tasmanian Fisheries Division. The southern Tasmanian whitebait stock is ndependent and is underfished.

(*g*) *Barracouta.*—Barracouta continues to be very mportant in the total Australian catch. This is largely due to the present demand for it for canning, which, however, may not be maintained. A full analysis of catch records has confirmed the earlier findings (of 1944) that such changes principally reflect variations n demand, and that the barracouta is under-exploited n even the present limited areas of the fishery.

Approximately 1,000 barracouta have been tagged from the F.R.V *Liawenee,* as part of an investigation to determine whether there are one or more stocks in south-eastern waters. Another phase of the research is the study of condition of this species, specimens of which vary greatly in weight for size. An investigation on "milky barracouta" is being made, in co-operation with the Zoology Department of the University of Melbourne.

(*h*) *Mullet.*—In Western Australia, 1,150 mullet were tagged during the year. One of these fish was tagged in Peel Inlet and was recaptured in the Swan River, which is the next river system to the north. This is the first direct proof of intersystem migration of mullet in Western Australia.

A paper on the economic biology of the mullet in Western Australia has been completed and a study on more purely biological aspects of its age and growth is in preparation. Similar papers are being prepared on the yellow-eyed mullet.

The estuarine fishery for mullet in Western Australia must be regarded as a low-level fishery. Mullet population has definitely declined in the Swan River since the early part of the century. As long as there is an adequate brood stock elsewhere to supply the estuaries there seems little biological reason to restrict the fishery, while there are probably good economic reasons to keep it as it is. The Shark's Bay mullet catch is being watched to detect any lowering in the proportion of older age groups under the more intensive post-war fishing.

(*i*) *Black Bream.*—Further tests on black bream have been carried out using the Petersen button tag fastened through the flesh of the back. This shows considerable improvement on the opercular tag. Movements traced by tagging are small and only one fish has moved from the estuary in which it was tagged.

(*j*) *Fresh-water Fisheries.*—The experimental work in relation to selective breeding in trout has continued and been extended to include both brown and rainbow trout. The first tagging experiment to follow the growth of fish under different conditions has been partly completed. A new type of tag for use on small fish is undergoing tests.

Routine work on pond culture has been continued and it is expected that the first addition of nutrients to the highland lake may be made in the spring. The lowland experimental dam has not proved satisfactory and experiments will be moved to another location.

(*k*) *Cowanyoung.*—Large commercial landings of Cowanyoung (*Trachurus novaezelandiae*) were made in Tasmania and were comparable with those taken in 1948.

(*l*) *Spanish Mackerel.*—General biological data on Spanish mackerel have been accumulated from northwest Australia, North Queensland, Torres Strait, and New Guinea. Further information on spawning seasons, spawning grounds, and migrations has been obtained.

4. CRUSTACEA AND SHELL FISH INVESTIGATIONS.

(*a*) *Crayfish.*—A continuous fishing test on *Panulirus longipes* was carried out at Pelsart Group in the Abrolhos Islands during the year. The intake of crayfish from the outer deep waters to the westward of the fringing reef was continuous, with a marked increase during July and August. It follows that any fishing to the westward of the outer reef walls will be to the detriment of the fishing areas on the lagoon sides of the reefs.

The fishing effort increased in intensity during the opening months of the 1949 season. The long closed season (September 1 to March 15) was beneficial. It would appear that the population estimates suggested in the last annual report are reasonably correct for the inter-reef grounds.

During June, 1949, a number of mid-stage larvae were taken at a point 100 miles west of Rottnest Island, and later numerous mid-stage larvae were taken at distances ranging from 25 to 35 miles west of Rottnest Island.

Technical work on the processing of crayfish was continued. Investigations in collaboration with the Division of Animal Health and Production had shown that blood copper values ranged from 43 to 208 gamma per ml. It was considered that this variation was correlated with variation in the liability to blackening of crayfish flesh, and processing methods were worked out on this assumption. The methods have been adopted by the commercial packers and the product is now satisfactory.

Specimens of the northern crayfish *P. versicolor* and *P. burgeri* were obtained from various areas between North-West Cape and Bedout Island, off Broome. The flesh was of excellent processing quality. Further investigation of this area is warranted.

Young specimens of the southern crayfish, *Jasus lalandii,* were obtained at various points on the south coast, ranging from off Denmark to Cape Reche.

(*b*) *Sand Crabs.*—Following representations by the Queensland Professional Fishermen's League alleging that female sand crabs of carapace width greater than 6 inches do not reproduce and therefore should be marketed, the Queensland Fisheries Department requested the Division to investigate the matter. Already several females in berry at a size greater than this have been taken, but more work is needed before recommendations can be made.

(*c*) *Oysters.*—A further 50 cases of the spat of the Pacific Oyster (*Ostrea gigas*) were imported during the year and laid out in the Pittwater area in Tasmania. The shipment of the previous year had thriven here whereas those sent to Oyster Harbour, Western Australia, had gradually died out. In March, 1949, the oysters of the 1947 shipment averaged 9 cm. in length and those of the 1948 shipment 3.6 cm. The older brood were in good condition over the summer and a spawning occurred in March. Whether spatfall will be satisfactory has yet to be determined. The experience gained from these shipments shows that the journey from Japan to Australia must be less than fourteen days to obtain a good percentage survival.

A paper on the effect of the orientation of cultch material on the setting of the Sydney rock oyster has been prepared for publication.

A brief survey between Geraldton and Onslow indicated a considerable source of the north-west rock oyster (*Ostrea cucullata* ?). In some places the oysters are small and stunted but in large areas they are of good quality. Near Carnarvon are several creeks which would be excellent cultivation areas.

(*d*) *Scallops.*—The predicted decline of the catch began in the 1948 season. The statistics supplied by the Tasmanian Fisheries Division continue to be scrutinized.

(*e*) *Pearl Shell and Pearl Culture.*—Field work of the programme on pearl shell and pearl culture was commenced in Thursday Island at the beginning of December. Because the field station buildings are still not completed, the field work has been very restricted.

5. OCEANOGRAPHY.

(*a*) *Oceanographical Investigations.*—The determination of annual productivity cycles in New South Wales, Tasmanian, and Western Australian waters was continued. In the south-eastern sector the existence of a bimodal production cycle with a progressive northward increase in the degree of summer nutrient exhaustion was again demonstrated. Further data on upwelling in the Port Stephens-Port Macquarie area were obtained. In the south-western sector, on the other hand, no comparable annual production cycle has been demonstrated, the nutrient level of these waters being near exhaustion level over the whole period.

The only offshore investigations during 1948-49 were those in the south-western sector from the F.R.V. *Warreen.* General absence of any well-defined lateral or upwelling exchange between shelf and slope offshore waters was demonstrated.

(*b*) *Estuarine Hydrological Investigations.*—(i) *Productivity and Zonation Studies.*—Routine hydrological examination of estuarine waters from New South Wales, Tasmania, and south-western Australia were continued. Monthly surveys of the summer-flood-dominated northern rivers of New South Wales were commenced in January, 1949, and have been continued. In the south-west area extra data on the post-flood development of zonation properties have been collected from some of the estuarine systems during 1948-49.

(ii) *Oyster Hydrology.*—The lease enrichment work of the previous year at Shell Point, New South Wales, has continued. It is evident that control plots are subject to periodic invasion by enriched mud and the effect of mud enrichment on oyster growth from this experiment will be difficult to determine exactly.

As a further check on the hydrological and biological effects of mud enrichment, a layer of mud in the spatting tank and the bottom deposits of a section of the marsh at Shell Point were treated with the enrichment mixture in July, 1948, and covered by sea water. A routine hydrological sampling programme has been carried out since that date. A marked difference in the rate of leaching of phosphates from the mud by the overlying water of the tank compared with that of the marsh appears to be governed by the pH of the water.

A pumping assembly designed to entrap planktonic organisms of a size above 1/200-inch has been designed and put into operation at Shell Point.

The 1948 data on tidal flat temperature conditions showed clearly the condition governing the development of a cold water front. The destructiveness of this cold front, however, can be realized only if it persists on the receding tidal phase down to the oyster-growing level. During the forthcoming winter season, therefore, efforts will be made to obtain data on this aspect.

Enrichment of a number of commercial leases in the George's River area has been carried out during this year. A long-term investigation of the effect of mud enrichment on a section of Tilligherry Creek, Port Stephens, New South Wales, has been commenced and should yield positive data on the commercial possibilities of this treatment.

Routine investigations of the hydrological and bottom mud properties of the Pittwater area, Tasmania, in which the Japanese oysters have been laid out, were commenced during this year.

(*c*) *Freshwater Hydrological Studies.*—The hydrological and bottom mud investigations of Lake Dobson and Penna Dam in Tasmania were continued.

6. PLANKTON INVESTIGATIONS.

Plankton hauls have been made at hydrology stations in Western Australia in the Shark's Bay, Abrolhos Island, Rottnest Island, and Albany areas. Series have also been received from Port Phillip Bay, east coast of Tasmania, Lord Howe Island, Coff's Harbour, Smoky Cape, and Port Macquarie. Regular monthly hauls have been made at Twofold Bay, Jervis Bay, Botany Heads, and Port Stephens. It has been observed that in hauls taken in Western Australia, Euphasiids, Ostracods, and Coelenterates appear in large quantities closer inshore than similar dominant numbers of Tunicates and Chaetognaths. Detailed examination of Euphasiids from Western Australian plankton showed the presence of large swarms of *Euphasia recurva* which is characteristic of the east Australian coast from Eden to Coff's Harbour. However, *Nyctiphanes australis* of eastern Australia, an important element in the food chain of fish, is absent from the plankton of the west.

Plankton and submarine light collections from *Warreen* and other research vessels have been sorted into families for the period 1938-49. Detailed work has continued on the groups Mugilidae-Atherinidae Pseudomugilidae and Gobiidae-Eleotridae. Most attention has been directed to collections of postlarvals from Princess Charlotte Bay (M.V. *Australia*) and New Guinea-Papua (M.V. *Fairwind*). Larval forms o Bregmacerotidae have been described and incorporated in a paper for early publication.

7. AERIAL OBSERVATIONS.

The aerial survey of salmon made in 1947 wa repeated this year in a chartered plane at the end o August. Salmon were located from west of Alban as far as Port Culver in the Great Australian Bigh the shoals being particularly dense on the beache several miles west of Port Culver.

8. TAXONOMY.

Work has been directed to the description of deep-sea ishes of the families Myctophidae, Sternoptychidae, nd Gonostomidae. A description of the fishes obtained y the F.R.V. *Warreen* during trawling tests in the hark's Bay area is being prepared. Collections of ustralian Gobiidae and Atherinidae have been ssembled. X-rays of a large number of Australian nd New Zealand fishes have been prepared and filed or study.

Two collections of fishes, one from Lord Howe Island ollected by the F.R.V. *Stanley Fowler,* and a larger ne of several hundred specimens from New Guinea, ollected by M.V. *Fairwind,* are being identified and will be listed and described.

Work on a card index of fishes has been continued. The section on sharks and rays is now nearing ompletion.

9. MUTTON BIRDS.

The joint field investigations into the Tasmanian mutton bird (*Puffinus tenuirostris*) by the Division and the Tasmanian Fauna board in the Furneaux Group have been continued. A hut has been erected on Fisher Island as a field station for the work. Longevity data for the species are being sought and the homing and dispersal habits of the birds are being studied. It is not yet established at what age the species commences to breed, nor is it known to what extent the young birds return to the island of their nativity or disperse elsewhere. Future work on Fisher Island is expected to provide essential data on these points.

Just prior to the commercial birding season in 1949, a total of 1,811 young birds was banded on the five commercial islands, compared with 1,847 in 1948 and 683 in 1947, to ascertain the intensity of the commercial operations and the degree of escapement of the young birds each year.

The mortality counts on Cronulla beach were continued during the last quarter of 1948 and again, for the sixth successive year, showed a relatively low mortality.

10. MISCELLANEOUS.

(*a*) *Microbiology.*—The study of marine bacteria and those in estuarine muds in Botany Bay was continued. The study of the diatoms occurring on the oyster beds in Botany Bay has yielded a number of species new to Australia.

(*b*) *Fouling by Marine Growths.*—New stations for fouling plates have been established at Cairns, Townsville, and Yamba. Recent work has shown that tubeworm fouling may be preceded by the settling of an encrusting bryozoan, *Watersipora cucullata,* which is copper tolerant and seriously reduces the efficiency of copper anti-fouling paints. This work suggests that the first few weeks' history of a vessel after docking determines the effectiveness of the anti-fouling paint.

(*c*) *Agar.*—A seaweed survey of North Queensland revealed a bed of *Eucheuma* suitable for agar manufacture. Recently, certain overseas techniques have been employed in the manufacture of *Gracilaria* agar, giving a greatly improved quality. It has also been possible to make and vary the properties of a very good agar from *Eucheuma.*

XI. FOOD.

1. GENERAL.

The preservation and transport of foodstuffs is of great importance to Australia as a food-producing country situated inconveniently far from the main food-importing nations of the world and with long distances separating its own population centres.

The Organization's work on food is undertaken chiefly within the Division of Food Preservation and Transport with main laboratories at Homebush, New South Wales, and branch laboratories at Brisbane (concerned with meat) and West Gosford, New South Wales (concerned with citrus fruits). A small independent Section of Dairy Research is working in Melbourne on dairy products. Work on dried vine fruits is in progress at the Commonwealth Research Station (Murray Irrigation Areas), Merbein (*see* Section 12 below). Co-operative investigations on wines are housed in the Waite Agricultural Research Institute, Adelaide (*see* Section 13 below).

Division of Food Preservation and Transport.—The nature and scope of the Division's research work have recently been reviewed. At the present time, all types of foodstuffs except cereals and milk products are covered, and the major methods of preservation are investigated. Related studies in physics, chemistry, microbiology and plant physiology are essential adjuncts. There is little doubt that the range of foodstuffs and processes being studied adequately covers present Australian needs, but insufficient attention is being given to many detailed problems in the major fields of investigation. This is due to difficulties in obtaining suitably qualified and trained staff and to inadequate laboratory accommodation. As it is unlikely that either can be overcome for some time, steps have been taken to reduce the number of investigations allotted to several sections of the Division so that the investigators can give more detailed attention to the major problems in their particular fields. Since the store of knowledge through which future advances in techniques can be made is derived from fundamental studies, care has been taken to increase the proportion of such work.

The work of the Division is arranged under a series of Sections whose work during the past year is outlined in Sections 2-11 below. The work described in Sections 8 and 9 was carried out in co-operation with the New South Wales Department of Agriculture.

Work at the Brisbane Branch Laboratory (*see* Section 5 below) has been seriously interfered with during the latter half of the year owing to repairs to the cold rooms, which were started in December, 1948, and are nearing completion.

In conjunction with the New South Wales Department of Agriculture, the Organization has built and equipped a small laboratory at West Gosford, New South Wales, for studies on the handling and preservation of citrus fruits. This laboratory was officially opened on 25th October, 1948, by the Honorable F. J. Finnan, New South Wales Minister for Labour and Industry. The Gosford Bulk Loading Co-operative Society Ltd. contributed materially to the establishment of this laboratory by making the required space available free of charge in their premises at West Gosford.

A committee for the co-ordination of fruit and vegetable processing investigations, consisting of representatives of the New South Wales Department of Agriculture, the University of Sydney, and this Organization has been formed to assist in the conduct of research work on food processing and related field investigations.

Much of the Division's work has again been possible only through the help in facilities and money which has been given by a number of individuals, organizations, and commercial establishments.

Dairy Research Section.—The development of the Dairy Research Section to a size more in accordance with the needs of the Australian dairy manufacturing industry is also limited by shortage of laboratory accommodation and staff. Plans and estimates for the Section's new laboratories at Highett, Victoria, have, however, been prepared and the prospects of obtaining staff also appear brighter.

As in previous years the Division of Industrial Chemistry has given valuable advice and assistance in many aspects of the Section's work.

The Section's work during the past year is outlined in Section 14 below.

2. Physics of Transport and Preservation.

(*a*) *Cold Store Survey.*—The results obtained in previous seasons have been analysed further. Measurements are being continued this season in one set of stores in which a number of different types of cooling and stacking systems are used.

(*b*) *Rail Transport.*—A further comparison of the performance of new and old types of louvred vans widely used for the transport of fresh fruit and vegetables has been carried out in co-operation with the New South Wales Government Railways. This was done with cargoes of bananas under extreme summer conditions. The results confirmed the tentative conclusions drawn from earlier work, namely, that there is a real difference in the efficiency of ventilation of the cargo in the two types but it is not great enough to be of practical importance in the carriage of bananas. Observations of air flow in some New South Wales and South Australian louvred cars were made in co-operation with Railways officers in order to obtain information on the effect of some proposed variations in design on the performance of the vehicle.

The temperature distribution on arrival in Melbourne in car loads of peas shipped from South Australia was studied. The "self-heating" problem was analysed theoretically and consideration given to improving conditions. Further tests are planned.

A test was carried out with a New South Wales M.R.C. type refrigerator car, with a cargo of frozen egg pulp, in order to determine the efficiency of this type of car in maintaining very low cargo temperatures when salt is added to the ice in the bunkers and the stowage is as favorable as seems feasible in ordinary practice. Observations were also made on a shipment of frozen egg with which dry ice was used as the cooling agent.

In co-operation with the Queensland Department of Agriculture, some measurements were made in a Queensland refrigerator car in order to obtain more precise data on the thermal properties of the vehicle and also to explore the effect of depletion of the bunker ice on the performance of the car.

(*c*) *Transient Heat Flow in Composite Walls.*—Dr. J. C. Jaeger has developed simple formulae for the solution of some of the most important practical problems of this type. His formulae were applied to an arithmetical study of the pre-cooling of some typical rail cars.

(*d*) *Evaluation of Canning Processes.*—The logical and mathematical basis of the usual methods for the evaluation of canning processes has been examined. It was concluded that the methods used at present may give results substantially in error. A paper outlining what is believed to be a reasonably complete solution of the problem has been submitted for publication.

(*e*) *Evaporation from Fruits.*—Measurements of the ratio of the rates of evaporation of apricots, peaches, and bananas to the rate of evaporation of geometrically similar wet bodies have been made. These data are particularly important in relation to the non-refrigerated carriage of fruit and vegetables. A study of the rate of evaporation of fruits in different positions in cases during storage, and the factors affecting it, has been started. Measurements have been made with oranges, pears, and apples, to investigate the effects of wrapping the fruit, of case liners which will prevent air exchange but not restrict diffusion appreciably, of water uptake by the case itself, and of vapour pressure difference between the fruit and the storage atmosphere.

(*f*) *Cooling of a Wet Body.*—Further calculations have been done and a few measurements made with sides of beef.

(*g*) *Vapour Pressure of Dried Foods.*—Further measurements have been made with dried peas.

(*h*) *Freezing.*—Rates of freezing of crayfish tails in export type packages have been measured in commercial freezing tunnels to obtain data required by the Department of Commerce and Agriculture.

Measurements and calculations of the rate of freezing cans of egg pulp have been carried out to provide data needed for the planning of a projected study of the performance and design of freezing tunnels for egg pulp.

(*i*) *Freezer Burn on Edible Offals.*—Experiments have been set up to determine the efficiency of a series of wrapping materials in controlling water loss in livers and kidneys in frozen storage. Small-scale experiments are also being carried out to determine the rates of water loss from frozen offals under known conditions and the relation between the amount and rate of water loss and the incidence of freezer burn. The water vapour permeabilities of some wrapping materials are being measured at —10° C.

(*j*) *Colour Measurement.*—The spectral distribution of light reflected from samples of beef fat has been measured and consideration given to colour discs and other means of obtaining a satisfactory colour grading technique for work on the quality of beef carcases.

(*k*) *Humidity Measurement.*—Work is continuing on the testing of instruments which might be used in various projects.

(*l*) *Conductivity Meter for CO_2 Measurements.*—A meter using a cell with external electrodes has been constructed and tested.

3. Food Chemistry.

(*a*) *Anaerobic Destruction of Ascorbic Acid.*—Following a suggestion that non-oxidative destruction of ascorbic acid may occur in canned foods, the anaerobic destruction of ascorbic acid was investigated. The initial studies have been made at 100° C. to obtain more rapid results, and the effects obtained need confirmation at lower temperatures.

In various buffers from pH 2.2 to 7.0 but with no other added substances, the maximum rate of destruction was obtained at pH 4.

As higher rates of destruction were obtained in fruit and vegetable extracts, it became apparent that some substances could exert an accelerating effect. A large number of substances have been tested, and the most definite effects have been obtained with fructose, sucrose, and hydroxymethylfurfural.

Oxalic acid is commonly used in the determination of ascorbic acid. Deterioration has been observed in solutions of oxalic acid on standing, and has been shown to be due to traces of hydrogen peroxide which develop in the presence of light.

(*b*) *Natural Coating of Apples.*—An additional fatty acid fraction has been obtained by saponifying the insoluble portion of the skin with alcoholic potassium hydroxide. This fraction appears to contain a high proportion of hydroxyacids. It was found to be almost entirely absent from the cell wall material of the flesh, A study of the changes in the coating fractions during orage and ripening is still in progress. The various chniques for determination have been critically comared. Increases in the oil fraction during storage ave been obtained over several seasons. An increase the insoluble portion of the skin was obtained in 948, and this is being investigated further.

(c) *Volatiles from Apples.*—A method for the colorietric determination of volatile esters (by conversion hydroxamic acids) has been developed, and the results f this work have been prepared for publication. Preminary measurements of volatile ester production were ade with Granny Smith apples in 1948 and more xtensive measurements are being made. The rate of olatile ester production has been found to increase with ime, the increase being greater in the more mature pples.

To facilitate identification of the acid portion of the sters, the saturated unsubstituted hydroxamic acids ontaining from two to eight carbon atoms have been eparated by paper partition chromatography. A eport on this separation is being prepared for publiation. A study of the esters from apples has indicated he presence of acids containing from two to six carbon toms, the predominant constituent varying with the amples of apples. Confirmatory evidence has been btained by mass spectrographic analysis in co-operaion with the Division of Industrial Chemistry. Tests re being made to determine the possibility of the ccurrence of unsaturated or substituted acids.

The identification of the alcoholic portion of the sters (after oxidation to the corresponding acids) is eing investigated.

The effect of a number of volatile substances on the evelopment of superficial scald in Granny Smith pples is being investigated in the present (1949) eason. The effect of the oil from the apple skin is also eing studied.

4. MICROBIOLOGY OF FOOD.

(a) *Clostridium botulinum Investigations.*—The rincipal factors which govern the stability of type A otulinum toxin when heated in canned vegetables have ow been elucidated. The heat stability is due mainly o the various ionized substances dissolved in the vegeable liquor. In canned cabbage the salts of common norganic and organic acids are sufficient to account or the observed protection, but in canned carrots other ubstances are also involved. Protection is afforded y both cations and anions, and their effectiveness epends both on the nature of the ions and on their oncentration. Multivalent ions with a hydrophilic haracter are particularly effective. The protective ffect of several different ions tends to be additive and he toxin has been found most stable in mixtures of igh ionic strength. The conclusion reached is that he time-temperature conditions necessary for the estruction of a given amount of toxin cannot be pecified unless the ionic environment of the toxin can e defined. Experimental work has been completed and prepared for publication.

Experiments on the influence of temperature on the growth of this organism were resumed, and fairly complete data for about fifteen of the strains available in his laboratory obtained. There is evidence of some variation between strains. The observations are being extended to cover the remaining cultures.

(b) *Heat Resistance of Bacterial Spores.*—The investigation of the factors affecting the germination of eat-treated spores has been resumed. This investigaion is particularly important in relation to the determination of adequate heat processes for non-acid anned foods. Increased recovery in media containing starch has been confirmed, and serum albumin and activated charcoal have been shown to be equally effective. The role of these substances is largely that of adsorption of inhibitory substances present in the media, and experiments have failed to reveal any direct adsorption from the spores themselves, although this possibility still exists. The inhibitory substances can be almost completely extracted with activated charcoal from the broth component of the medium. The nature of these inhibitory substances is being investigated, and they are believed to be unsaturated fatty acids. Linoleic acid has been shown to inhibit spore germination, especially of heat-treated spores, and this inhibition is counteracted by the presence of activated charcoal in the germination medium.

Some attention has been given to the germination of unheated spores, and with some species to its stimulation by sub-lethal heating. One strain has consistently given over a fifty-fold increase in the number of germinating spores, upon heat activation. The phenomenon is independent of nutrient conditions and the maturity of the spores. So far the ionic nature of the suspending fluid has been shown to have little effect.

(c) *Disinfection by Cationic Detergents.*—The bactericidal properties of two compounds were further tested against two species which showed differing pH-susceptibility relationships. Those were studied in relation to rate of disinfection, inhibition of respiration, and loss of phosphorus from treated cells in the presence of radio-phosphorus. So far the results have not revealed any particular mode of action for this class of anti-bacterial. Some of the results appear inconsistent with existing theories. These investigations have now been suspended at Homebush, but some aspects of the work are being continued during the investigator's term of post-graduate study in England. The results so far obtained have been prepared for publication.

(d) *Mould Growth Studies.*—The study of the water relations of a mould adapted to growth in a dry environment has been continued. Fairly complete data have now been obtained. As the taxonomic position of the organism is uncertain, a detailed study of its morphological characters and mode of reproduction have been undertaken in co-operation with Dr. Fraser of the New South Wales Department of Agriculture. Fairly detailed data have been obtained on the rate of growth of this fungus at various pH levels. The optimum pH is in the region of four, with little growth above five.

(e) *Mould Wastage of Stored Fruit.*—Fundamental studies are being started on the problem of mould wastage in fruit, concentrating on the host-parasite relationship. Some work has been commenced on the *Gleosporium*-type rots in apples. A preliminary study of the microflora of the lenticels of two varieties of apple is being carried out at the Botany Department of the University of Melbourne, where the work is accommodated at present.

(f) *Water Relations of Media.*—A study of the vapour pressure isotherms of some bacteriological media in the range of 0.9 to 1.0 water activity was commenced.

5. MEAT.

(a) *Weight Losses.*—In connexion with studies on the cooling of a wet body, work has been commenced on the measurement of weight loss during chilling from sides of beef. These measurements have been supplemented by other determinations covering deep butt temperatures of the beef, air temperatures, and relative humidities.

An investigation on weight losses from pork sides during freezing and subsequent storage, specifically to investigate the differential results achieved by various methods of chilling and freezing, has commenced. In this work the Queensland Meat Industry Board is co-operating by making available the necessary supplies of pork as well as the chilling and freezing facilities.

(*b*) *Aerosols and Storage Rooms.*—The work on the effect of aerosols on suspensions of bacteria in the air of storage rooms has been held up because the experimental cold rooms were out of operation. Some related work on the extent of contamination in industrial chillers, carried out with a slit sampler, showed a very high and comparatively constant microbial content in the air.

(*c*) *Investigations on Ozone.*—Considerable time was spent on the fabrication of an all-glass system for studies on the effect of low concentrations of ozone on the growth of micro-organisms on ox muscle. This work has been deferred whilst the refrigerated chambers have been undergoing repairs.

6. Fish.

(*a*) *Survey and Advisory Work.*—A survey of fish preservation problems was carried out in Western Australia, and first-hand information obtained concerning a condition of black staining which had caused deterioration and rejection of some consignments of frozen raw crayfish tails exported to the United States of America (*see* Chapter X., Section 4 (*a*)).

Assistance has been given to the Fisheries Division of the Department of Commerce in the framing of Exports (Fish) Regulations.

(*b*) *Fish Canning.*—Investigations have included work on the tenderizing of Australian salmon, the inclusion of tomato in cans of fish, and a study of the effects of frozen storage on the canning quality of pilchards.

(*c*) *Shark Flesh Investigations.*—Work has proceeded on the post-mortem development of ammonia in shark flesh and the breakdown of urea during retorting and subsequent storage of canned shark. A modification of the Conway and Byrne method for estimation of volatile bases has been investigated.

(*d*) *"Milkiness" in Fish.*—Studies have been made of the condition known as "milkiness" which is frequently found in the flesh of barracouta and kingfish. It has been found that a very active proteolytic enzyme system is associated with the causative organism (a protozoal parasite). The effects of temperature and pH on the activity of this enzyme system have been investigated and samples of protein hydrolysates prepared from infected fish muscle. (*See* also Chapter X., Section 3 (*h*).)

7. Eggs.

(*a*) *Abnormalities Resulting from Ingestion of Products from Malvaceous Plants.*—In confirmation of American work, it had previously been indicated that pink or amber whites and "custard-like" yolks which had been rather prevalent in eggs exported from Australia were probably caused by the inclusion in the hens' diet of the products of malvaceous plants, such as the seeds of marsh-mallow.

In a further series of experiments, these results were confirmed, and it was also shown that the ingestion of 5 per cent. of marsh-mallow seeds in the mash resulted in a marked decline in the productivity of the hens. Oiling of the eggs caused a significant increase in the incidence of abnormalities in the yolks during storage as compared with unoiled eggs. Ingestion of leaves of the marsh-mallow will probably cause abnormalities in the eggs. From these results, it is clear that the eradication of mallow plants on poultry farms is most desirable.

(*b*) *Effects of Oiling.*—All eggs exported to th
United Kingdom are now required to be oiled. Inves
tigations were continued to study the effects on aspect
of quality important to the consumer and to ascertai
the basic cause of any effects of oiling.

From the results obtained so far, it is doubtfu
whether oiling consistently results in superior qualit
after storage for periods of up to three months, excep
in reduced loss of water.

(*c*) *Measurements.*—Cracking of the shells is no
the main form of wastage in exported eggs, and ha
generally been higher in the larger eggs.

While there are obviously many causes of seriou
cracking, for which appropriate remedies can be sug
gested, it is not certain whether the present sizes of case
and fillers afford adequate protection. Whether suc
materials are satisfactory in shape and size can only b
decided in relation to the sizes of the eggs in eac
weight-range which the fillers are required t
accommodate.

In order to provide the facts on which a ration
decision on this question could be made, the length
maximum diameters, and weights of some 36,000 egg
in each weight-grade have been obtained in New Sout
Wales and South Australia. This task was made possib
by the provision of a special high-speed measurin
machine, designed and built in the Organization
National Standards Laboratory. The data are no
being analysed statistically.

8. Fresh Fruit and Vegetable Storage—Plant Physiology and Biochemistry.

(*a*) *Metabolites in Apples.*—A paper dealing wi
biochemical changes in apples in cool storage duri
1946 and 1947 and referring particularly to changes
carbohydrates and organic acids has been accepted f
publication. A second paper which deals with chang
in the nitrogen fractions of apples is being prepare
Analytical work on storage samples from the 19
crop has been continued for comparison with earli
work and includes samples from both flesh and sk
regions of the fruits. An unknown low molecul
weight carbonyl compound, apparently associated wi
apple respiration, has been isolated and identification s
being attempted.

Work on the effect of nitrogen upon the keepi g
quality of apples has also been carried out in Tasman a
by the Division of Plant Industry (*see* Chapter II ,
Section 16 (*b*)).

(*b*) *Apple Growth Experiments.*—Early in the ye r
the experimental work on developing Granny Smi h
apples of the 1947-48 season was completed in collabo -
tion with Miss J. Bain, of the Botany School, Univ -
sity of Sydney. This work included a study of fr t
size, cell size and number, carbohydrates, nitrog n
fractions, organic acids, and respiration in the devel -
ing fruits, sampled fortnightly through the seas .
This work has now been incorporated in an inter n
report and forms the basis of the programme to ch k
the observations on fruit of the 1949 season.

(*c*) *Organic Acid Metabolism.*—Experiments in t
shoots of *Avena* seedlings have been continued as t s
material has been found very suitable for study of e
relation of organic acids to respiration. Citric, ma e,
and alcohol dehydrogenases in this tissue have b n
studied with the Thunberg technique.

(*d*) *Respiration in Plant Tissue.*—In view of e
importance of respiration in various aspects of e
Section's work, it was decided to make a thoro h
survey of the literature to collect the evidence for e
chemical stages in respiration of higher plants d
to make it available to members of the Section. e
respiration rates of cut tissue of apples and of e

whole fruits have been compared and the effects of various solutions on the cut tissue have been studied. In carrot tissue, collaborative work with Mr. D. Weeks (Botany School, University of Melbourne) has shown that the salt respiration, previously known to be inhibited by cyanide, is also inhibited by carbon monoxide in the dark and is light-reversible. This establishes the participation of cytochrome oxidase in this respiration. In conjunction with respiratory studies, isocitric acid, coenzyme I., flavoprotein, and cytochrome oxidase have been prepared.

(*e*) *Organization of the Plant Cell.*—Experiments on the early stages of absorption after the addition of salt to carrot tissue in water were completed and have established the rapid penetration of the salt in the non-living portions which amount to about 20 per cent. of the tissue. These results have been analysed mathematically in collaboration with the Physics Section and a paper has been prepared. Experiments with 2:4 dinitrophenol have shown that the salt accumulation rate is reduced without inhibition of the respiration; experiments are in progress to determine whether this is a direct effect on the accumulatory mechanism or an indirect effect, due to increased permeability of the cell membrane.

(*f*) *Nitrogen Metabolism in Plants.*—A review of the literature on nitrogen metabolism published between 1938 and 1948 was published. Experiments on the changes in the soluble and protein nitrogen in apples in storage are being continued at different temperatures to examine the magnitude of the protein synthesis.

(*g*) *Respiration Measurements.*—In collaboration with the Physics Section, a radio-frequency method for conductivity determinations has been developed and is being applied to measurement of carbon dioxide.

9. FRESH FRUIT STORAGE AND TRANSPORT—TECHNOLOGY.

(*a*) *Skin Coatings for Apples.*—Some further progress in the preparation of this work for publication has been made. A paper dealing with this technique was read at the Hobart Meeting of the Australian and New Zealand Association for the Advancement of Science.

(*b*) *Orchard Variability Experiment with Apples.*—Fruit of the 1948 season was examined after the standard time of cool storage and again after the standard post-storage period. Less fruit of the 1949 crop has been stored; this is due partly to the light crop in the experimental orchards and partly to a reduction in the experiment until the results of earlier years have been collated.

(*c*) *Maturity and Storage Studies with Apples.*—This project is aimed at determining the validity of a constant number of days from full blossom as a criterion of maturity for storage. Fruit stored in the 1948 season was examined and fruit of the 1949 season has been put into storage. Observations on blossoming of Delicious and Granny Smith trees at Orange were continued.

(*d*) *Cool Storage of Peaches and Nectarines.*—Experiments carried out in previous years have been repeated and sufficient information has now been accumulated for publication of an account of the best methods for storage and ripening. Factors investigated included maturity, partial ripening before storage, temperature of storage, gas storage, and temperature of ripening.

(*e*) *Storage of Lemons.*—Lemons from the Gosford area were placed in store under controlled temperature and humidity for comparison with replicate samples in orchard shed storage. Mould wastage under the controlled humidity conditions was high and was considerably affected by the maturity of the fruit and the condition of the trees. In orchard shed storage, mould wastage was low but shrivelling was considerable and greatly affected by maturity and size of fruit. The results of this work have been incorporated in an interim report and form the basis for the programme in the current season. It has been decided to omit the experiments on controlled humidity storage in the current season.

(*f*) *Citrus Wastage Experiments.*—Preliminary experiments with Valencia oranges were organized to determine the difference in mould wastage between fruit handled by normal commercial methods and experimentally treated fruit. The results of this work have been given as a report to the Citrus Wastage Committee, a joint C.S.I.R.O. and New South Wales Department of Agriculture Committee, and a programme for the 1949 Washington Navel season has been begun; this aims at determining the relative importance of orchard factors and handling in influencing mould wastage.

(*g*) *Low-temperature Injury in Citrus Storage.*—As it is often necessary to hold fruit in cool storage for short periods before shipment, the Section was asked by the Department of Commerce to determine how long oranges can be held safely at 32° F. without developing disorders. Experiments with both Washington Navels and Valencias from inland and coastal areas have been completed and a report has been submitted.

(*h*) *Storage of Pears.*—The effects of delay before storage and rate of cooling in store on the life of Packham's Triumph pears were studied. Samples delayed for various periods and samples cooled at different rates were removed from storage at 32° F., ripened at 68° F., and examined for quality.

A severe outbreak of brown heart, a disorder due to carbon dioxide injury, which occurred in Winter Cole pears in commercial gas storage, led to an investigation of the possible causes, since earlier work in this variety had not indicated any risk under the conditions of gas storage used. It seems that under some conditions, as yet unknown, the Winter Cole variety is particularly susceptible to carbon dioxide concentrations which are safe at other times.

(*i*) *Maturity Studies with Peaches.*—The work on the relation of the maturity of fruit to time of blossom has been continued in collaboration with officers of the Bathurst Experiment Farm.

10. CANNING AND FRUIT PRODUCTS.

(*a*) *Vegetable Canning.*—Accumulated experimental data on the varietal and maturity aspects of canning tomatoes will shortly be prepared for publication.

The canning quality of thirteen varieties of green peas grown by the New South Wales Department of Agriculture at Oberon, New South Wales, was assessed. Greenfeast variety was outstanding in field factors, including yield, and also in the colour and flavour of the canned product. Witham, Wonder, Emperor, and Perfection were rated next in that order. Green Admiral, Canners King, and Badger received the lowest preferences. Data on maturometer-alcohol insoluble solids relationship were obtained for all varieties.

Experimental work was continued on a restricted scale to define the relation between moisture content of sweet corn at harvest and its corresponding canning quality. The results of work carried out in previous seasons have been collated, and the manuscript will be submitted shortly for publication.

Sample material from the ½-acre plot of asparagus at Hawkesbury College River Farm was tested for the effect of delay between cutting and processing on the development of fibre and bitter flavour. The small amount of material available showed no detectable differences due to treatment, and it will be necessary to repeat the work on a larger scale in the next season.

The rate of development and canning quality of three varieties of beetroot, Asgrow Canner, Detroit Dark Red, and Improved Detroit, were investigated by harvesting and canning the roots at regular intervals. The examination of the canned material has not been completed.

The relation between maturity and canning quality of the Oxheart variety of carrot was determined by the procedure used for beetroot. In the case of both vegetables it is probable that the work will confirm previous observation that, for best quality, they must be harvested for canning during the period of rapid enlargement of roots.

Cultural difficulties associated with the production of the popular Blue Lake Stringless canning varieties of bean were solved by the use of wire trellises. An excellent yield was obtained, and the beans were canned at a range of maturities. The canned product has not yet been assessed for quality.

At the request of the Navy Bean Board of New South Wales several samples of navy beans of high moisture content as a result of rain during the harvesting period were dehydrated to the 12 per cent. moisture level and subsequently tested for canning quality. The canned material was comparable in quality with that prepared from normal beans. The result of the test is of considerable value to growers.

Work on the firming of vegetable tissues by immersion in warm water prior to canning was continued. The original treatment for 30 minutes in water at 120° F. has been reduced to five minutes in 2 per cent. salt brine at the same temperature. Fundamental studies of the phenomenon are to be undertaken.

(*b*) *Fruit Canning.*—Results from the freestone peach programme of 1948 indicated that some improvement in texture of the fruit was achieved by the thermo-rotation technique. The programme for 1949 therefore included fifteen varieties supplied by the Bathurst Experiment Farm of the New South Wales Department of Agriculture. All were processed by thermorotation. Examination of these samples, which include white and yellow fleshed varieties, has commenced.

Clingstone peach canning results from the previous season at Shepparton were presented at a combined Peach Canning Conference held in November, 1948, at Shepparton. Representatives of canners, growers, Department of Agriculture, and C.S.I.R.O. were present. General agreement was reached that several of the varieties presented were superior to the standard canning varieties, and it was decided to repeat the work during the 1949 season. Two officers, with the assistance of the Victorian Department of Agriculture and the Shepparton Fruit Preserving Company, canned some 63 varieties, seedlings and experimental crosses, during January-March 1949. Examination of these samples has not been completed.

A small pack of rockmelon was canned using fruit grown at the Hawkesbury Agricultural College. The packs were prepared from diced and segmented fruit and were processed by thermorotation. Results indicate that thermorotation eliminated the tendency to textural breakdown in this product.

Preliminary work has begun on the canning of bananas at the request of the Queensland Department of Agriculture. Results so far indicate the necessity for processing in water at 212° F. and the need for acidification of the syrup to permit this procedure. A product attractive in appearance and texture but slightly acid in flavour has been prepared.

(*c*) *Fruit Juices.*—For the fourth successive season the effect of Bordeaux sprays in causing bitterness in the juice of mature valencia oranges has been confirmed. This year an opportunity was presented by Mr. H. W. Cottee to lay down a long-term experiment on young trees at Kulnura, New South Wales, where the effect of Bordeaux sprays will be compared with that of a number of other sprays.

Chemical studies on the nature of the bitter principle, limonin, which causes the bitterness in orange juice, have progressed during the year and investigations have continued in order to elucidate the structure of this rather intractable substance. It is known that limonin is a ketone and a dilactone and that one of the lactone groups is probably 2,3-unsaturated. A manuscript reporting these findings has been prepared for publication. It now appears likely that the second bitter principle mentioned in the last annual report is an oxidation product of limonin produced during the extraction process since the same substance has been prepared by performic acid oxidation of limonin.

A project was commenced during the second quarter to follow the loss of ascorbic acid from canned orange juice stored at 86° F. and 32° F. Cans have been examined at regular intervals, and in the relationship between ascorbic acid and time a slight drop was noted in juice stored at 86° F. after 1,000 hours. This loss has continued during the subsequent storage period. At 32° F. the drop was less apparent. Oxygen was shown to have an effect on the rate of loss of ascorbic acid. In de-aerated vacuum-packed juice, little difference in ascorbic acid loss was recorded between plain and lacquered cans after 1,000 hours storage. In non-de-aerated juice, sealed cold at atmospheric pressure, there was a difference in the ascorbic acid retention between plain and lacquered cans, the juice packed in lacquered cans showing a lower ascorbic acid content 100-200 hours after processing. This difference continued through the storage period.

Following the successful marketing in America of a variety of canned blended fruit juices, a series of apple juice blends was prepared. The combinations tried were apple and youngberry, apple and boysenberry, apple and lime, apple and grapefruit, apple and pineapple, and apple and passionfruit. The most promising of these blends, among which apple and passionfruit was outstandingly attractive, will be introduced to the local fruit juice industry.

(*d*) *Lacquer Investigations.*—The search for a satisfactory "sulphur-resisting" lacquer, which has been carried on for some time in co-operation with Australian lacquer manufacturers, now appears to be approaching success. A lacquer has been developed which combines the desirable properties of protective value, mechanical resistance, and attractive appearance. This lacquer represents a radical departure from normal varnish formulations. If it can be manufactured successfully on a large scale it will be given extensive trials with a variety of commercial canned foods. The work on oleo-resinous "sulphur-resisting" lacquers has also led to a closer definition of the optimum level of added zinc oxide for satisfactory protective qualities. This level appears to be close to 8 per cent. of zinc oxide in the dry lacquer film.

(*e*) *Equipment.*—The thermoroto machine was structurally modified to increase the range of operating speeds. In an attempt to define rate of rotation corresponding to maximum rate of heat penetration in different types of packs, cine-photographs were taken of materials rotated in transparent plastic cans. An analysis of the films has still to be made.

11. DEHYDRATED FOODS.

(*a*) *Vegetables.*—Investigations on the varietal uitability of onions for dehydration have been connued, in collaboration with officers of the Victorian epartment of Agriculture, who have arranged the rowing and harvesting of the material. This project as reached the stage where it is apparent that, of xisting varieties, Australian Brown is the most suitable for dehydration. It has, however, several defects. he Victorian Department of Agriculture is attempting eliminate the objectionable purple pigmentation by election methods, and definite progress is being made. he data which have been accumulated on onion arieties indicate, however, that to attain the qualities equired for dehydration, viz. freedom from pigmentaion, good shape, high solids content and pungency, ng-keeping quality, and suitable skin characteristics facilitate peeling, breeding work will be necessary. 'he data obtained should be valuable in determining a uitable breeding programme.

A survey has been made of the temperature and airpeed distributions in two dehydration tunnels in a ommercial plant at Scottsdale. A report on this urvey has been prepared and certain modifications to mprove the performance of the tunnels have been uggested.

The Monier-Williams method for determining ulphur dioxide has been studied and a modified techique and apparatus devised. This modified method as been successfully applied to a wide range of foodstuffs.

The examination of data from the factorial experiments started in 1945 has been completed, and the reparation of the material for publication is nearing ompletion. This experiment has served to provide more precise data on the effects of varying levels of lanching, sulphiting, time and temperature of drying, and the time and temperature of storage on the storage ife of a range of dehydrated vegetables packed in air and nitrogen. The analysis of the data also revealed many significant interactions between these variables.

(*b*) *Fruit.*—Reports have been prepared on the nvestigations conducted during the 1947-48 season. Samples of fruit which were dehydrated after steeping n sugar syrups (glacé fruit) showed little deterioration during storage, even at 30° C., suggesting that sugar may markedly influence the storage life of dehydrated fruits.

Experimental work on the production of glacé peaches has been hampered this year by the poor quality of fruit available. The prevalence of brown rot resulted in the use of rather immature fruit. However, further useful data on moisture content, sulphur dioxide concentration, and the ratio of invert sugar to sucrose have been accumulated. Storage experiments with the material from this work are now in progress.

Preliminary experiments have been conducted with glacé apricots, and the results will be used in designing further trials next season.

Inquiries about the possibility of dehydrating bananas have led to some preliminary experiments with this fruit. Its general behaviour during drying has been studied and a dried product of attractive appearance has been obtained. The factors which appear of greatest importance are maturity, sulphur dioxide concentration, and final moisture content. Further trials with bananas are to be made later this year.

(*c*) *Dried Meat.*—A study has been made of the influence of the sex of the sheep on the palatability of dried mutton, especially on the "stringiness" of the product. This was carried out over a range of cooking times. The effects of sex were found to be small compared to the variations due to the individual carcass.

The effects of age of animal and the storage of the carcass were studied with a group of animals of uniform origin which had been pastured together for several months. The interpretation of the results of this work was rather difficult as the animals of different ages reacted differently to a reduction in the quality of the pastures. Arrangements are in hand to repeat the work under conditions where the feeding can be maintained at a high level.

The greater part of the year's work has been concerned with the preparation of concentrates from the cooking liquors and the return of these to the meat during drying. The factors studied have included the source of the liquor, the vacuum during concentration, the extent of concentration, and the method and time of adding to the meat. This work is being coupled with storage investigations to give detailed data on the effect of moisture and fat levels on the storage life of dried meat with and without added liquors and with blocking and carbon dioxide or nitrogen packing.

12. DRIED VINE FRUIT.

Investigations on the dipping and drying of sultanas were continued at the Commonwealth Research Station (Murray Irrigation Areas), Merbein.

(*a*) *Dipping.*—Further work was carried out on certain sulphonated oils, fatty acid esters, sulphated fatty acid esters, and wetting agents to determine their effectiveness in sultana drying as compared with the usual vegetable oil emulsions used in cold or heated dipping mixtures. The effect of surface tension on the wetting rate and the amount of dip mixture applied is also being studied.

The effect of potash strength in the cold dip on the drying rate of sultanas was re-investigated under adverse drying conditions. Results showed that, with the dipping mixture used, dips containing 1, 2, and 5 per cent. potassium carbonate gave almost the same drying rates, which is in agreement with previous results obtained under more favorable weather conditions.

Investigations with heated bulk dips showed that by heating the potassium carbonate-oil emulsion mixture used in the cold dip to 120-140° F. the drying rate of the dipped sultanas was considerably improved without any adverse effect on quality. By using suitable potassium carbonate-caustic soda mixtures heated to 160-170° F. it was possible to "hot dip" 50 dipping buckets at a time.

In dipping trials on Gordos, fruit dipped by the caustic soda dip heated to 200° F. dried about three days faster than fruit processed by the mixed dip. The caustic dip, however, gave slightly the better results after deseeding.

Investigations on mould control during unfavorable weather while fruit was drying on the racks have shown that adequate sulphuring with the fumes of burning sulphur is effective in preventing mould growth and improves the colour of the fruit. It is essential to sulphur before serious moulding has occurred.

Further investigations on the use of potassium propionate in hot and cold dips have shown that this substance is an effective fungicide when used at the rate of 1 per cent. in the dipping mixture, and has no adverse effect on the drying rate of the fruit.

Further work on sulphite temperature dips containing potassium or sodium sulphite and caustic soda instead of the usual potassium carbonate and caustic soda have shown that these dips give a drying rate at least equal to that of the standard mixed dip, while the colour of the fruit is lighter, and there is some protection against mould growth during unfavorable weather.

(*b*) *Sulphuring.*—Investigations on the sulphuring of sultanas in a sulphur chamber with the fumes of burning sulphur before dipping have shown that it is possible to obtain appreciable protection against attack by moulds by sulphuring for about half to one hour. By sulphuring for a short period, a quarter to a half hour, it was found possible to change the colour of the fruit from green to light brown, without much sulphur dioxide being retained by the dried fruit. This procedure may prove useful in eliminating "green tinge" in the cold dip process.

(*c*) *Other Investigations.*—In the packing house treatment of rain-damaged sultanas, the oil emulsion detergent washing treatment developed during 1947 for the treatment of rain-damaged currants has proved useful in salvaging badly damaged sultanas.

The results obtained in commercial practice on the use of "N.D.G.A." in retarding the development of rancidity in peanut oil applied to dried fruits during packing indicate that the method of application developed is satisfactory.

13. WINE.

Co-operative work directed by the Committee on Oenological Research, comprising representatives of the Organization, the Federal Viticultural Council, the Waite Agricultural Research Institute, and the Australian Wine Board, has continued at the Waite Agricultural Research Institute.

(*a*) *Sherry Investigations.*—The investigation of the influence of various factors on the growth and metabolism of the film-forming yeasts used in the production of sherry has continued during the year.

It has been found that vigorous growth of these yeasts on wines is usually accompanied by a marked fall in the oxidation-reduction potential of the wines and in many cases results in restricted and irregular accumulation of acetaldehyde and development of the desired sherry flavour and aroma. On the other hand, conditions which favour a moderately vigorous film growth frequently result in a superior product. Control of temperature and oxygen supply has been shown to have an important effect on the quality of the product and the influence of these and other factors is being further studied.

(*b*) *Collection of Yeast Cultures.*—The quality of wines and the efficiency of alcohol production depend in part on the strains of yeasts used for fermentation and it is well known that strains of yeasts differ in their suitability for different conditions. Accordingly, at the request of the Australian Wine Board the Committee has extended its research programme to include the establishment of a collection of tested strains of wine yeasts selected for Australian conditions and requirements. About 90 strains of wine yeasts have so far been collected from local and overseas sources. Examination of them and the development of laboratory techniques to test their suitability for different conditions has been commenced.

14. DAIRY PRODUCTS.

(*a*) *The Utilization of Skim-milk Solids.*—To further the Section's objective of aiding all developments leading to the better utilization of milk solids, research officers have been sought for further work on the addition of skim-milk powder to bread and for studies on other forms of skim-milk use. No appointment for the work on bread has yet been possible. For work on other aspects of skim-milk utilization, arrangements to obtain the services of a German scientist who has done much to develop the manufacture of egg substitutes from skim-milk are proceeding satisfactorily.

Further experimental batches of Milei whole-egg and egg-albumin substitutes were prepared at a commercial factory under conditions which, although the best available, were not entirely suitable. The product was tested by the Division of Food Preservation and by the Ministry of Food in Great Britain. The reports were encouraging in some respects but suggested that these products require improvement before they are likely to command any extensive market. Further work has been left until the specialist on these products is available.

(*b*) *Weed Taint in Butter.*—The field studies on weed-tainting of butter were continued in Queensland during the year and are now substantially complete. While the earlier work had shown the importance of *Coronopus didymus* as a source of weed taint, definite evidence was obtained from the feeding tests this year that *Lepidium hyssopifolium* and *Lepidium bonariense,* very widespread winter weeds in some Queensland dairying districts, were the cause of a most unpleasant taint. This becomes apparent only after the cow has fed for several days on the weed. The chemical substances responsible for the taint were found to be indole and skatole. These compounds are virtually impossible to remove from cream—severe heating followed by prolonged vacuum treatment caused little or no diminution of the indole or skatole content in experimental batches.

Further tests with the hypochlorite treatment for the correction of *Coronopus* taint showed that where this taint is intense the treatment is of no value—in these cases its effect is to alter rather than to remove the taint. Other forms of chemical treatment were no more effective. The year's work has therefore greatly diminished the prospect of finding cream treatments which will correct weed-taints, and emphasis must now be placed on alteration in agricultural practice as the solution to the weed-taint problem.

Of the other weeds studied, *Rapistrum rugosum* was found to cause a characteristic taint. Tests with *Apium leptophyllum* confirmed earlier tests that it does not cause appreciable tainting. *Opercularia,* suspected of causing the taint found to be due to *Lepidium,* failed to cause any off-flavour.

The source of the indole and skatole which is found in the milk fat of cows fed *Lepidium* spp. is by no means apparent. The plant itself contains no high concentration of these compounds, and the content of tryptophane, a possible parent substance, is normal. The plant may affect the types of behaviour of bacteria in the rumen, giving rise to greater production of indole or skatole, or it may interfere with the normal excretion of these products from the blood stream. Further information is being sought by animal feeding tests. The Biochemistry School of the University of Melbourne and the Division of Animal Health are participating in this work.

Work on the isolation of the particular compounds responsible for *Coronopus* taint has continued. Supplies of the weed air-freighted from Queensland were subjected to autodigestion followed by steam distillation and ether extraction. A semi-micro spinning-band vacuum fractionating column has been built for use in separating the compounds present in the extracts. Chromatography is also proving a useful tool for this purpose. The Division of Industrial Chemistry has given valuable assistance in the use of infra-red absorption and mass spectrometer measurements for the identification of compounds. It is possible that knowledge of the chemical nature of the compound responsible for the flavour may allow the development of a treatment which will remove it from the cream.

These studies have another important aspect, they re resulting in the development of techniques applicble to the isolation and identification of flavourroducing substances in dairy products in general.

(c) *Testing of Continuous Butter Processes.*—tudies on behalf of the Australian Dairy Produce Board of the Alfa continuous butter process have ecently been completed and a report prepared. The uality of the butter produced, and the economics and racticability of the process in comparison with normal hurning, were tested over a period of one year. While fficers of the New South Wales Department of Agriulture have carried out the major part of this work, he Dairy Research Section has also spent considerable ime on it. An officer of the Section spent two months t Lismore during the period of yield trials, microcopic examination of the structure of the butter was ndertaken, and copper determinations on stored amples are being carried out continuously. While his work is of obvious direct value to the Australian airy industry, it is also providing useful additional nowledge on butter structure and the factors which may affect quality.

Testing of the New Way process has not yet commenced, but studies on the suitability of various brines, nd on heat transfer in the extruder, have been made to ssist the development of this Australian process.

(d) *Oxidized Flavour in Milk and Butter.*—While here is much circumstantial evidence that when oxidized flavours first develop in some dairy products it is he phosphatide rather than the fat which is undergoing hange, the direct evidence on this point is both limited nd unsatisfactory. A useful line of investigation has een suggested by our observation that butter fat xtracted with solvents from milk or cream shows different oxidation values from fat obtained by churnng and melting the butter. The experiments carried ut have been designed to study the consistency of this ffect, the conditions under which it occurs, its relation o phosphatide content, and to oxidized flavour in arious products.

(e) *Mineral Sediment in Sweetened Condensed Milk.*—An Australian manufacturer of sweetened condensed milk has for many years been experiencing trouble with he development, within a few weeks of manufacture, f a fine-grained mineral sediment in the product. Some other Australian condensed milks also show this defect. Mineral sediments have been reported elsewhere in unsweetened but not in sweetened condensed milk. The mineral material was isolated and analysed and found to consist essentially of hydrated calcium itrate with traces of magnesium, phosphate, carbonate, and also protein. An investigation of the extent to which this deposit occurs in Australian condensed milks, its relation to the calcium and citrate contents of he milks, and the effect on the deposit of storage temperatures, is at present under way.

(f) *Other Investigations.*—Further work on the use of rennet casein for glue was directed towards establishng a satisfactory formula for direct preparation of glue from this casein. The work was developed in close co-operation with the Division of Forest Products.

The development of spore-forming bacteria in tins of processed cheese exported from Australia has caused rouble over recent years. At the request of the Department of Commerce and Agriculture and of the particular firm concerned an officer of the Section visited the factory to determine to what extent laboratory investigation was called for and to give advice on technical control measures.

The value of a new plastic wrapping developed in he United States for wrapping of butter under taintng conditions, particularly when packed in *Pinus nsignis* boxes, has been studied.

XII. FOREST PRODUCTS.

1. General.

Australia possesses a great variety of timbers, many of which are of considerable commercial value, while some are unexcelled in the properties which make them suitable for specific uses. However, fundamental data regarding properties, potentialities, and correct methods of treatment are essential to the full and proper exploitation of Australia's timber resources.

The work of the Organization in this field is carried out by its Division of Forest Products with laboratories in Melbourne. Some work on timber pests has also been undertaken by the Division of Entomology (*see* Chapter IX., Sections 12 and 13 (*d*)).

Division of Forest Products.—The work of this Division during the past year is outlined in the remainder of this chapter.

The housing programme and the general post-war reorganization of Australian industry have resulted in greatly increased consumption of timber. Whereas before the war Australia imported approximately one-third of its timber requirements, now the increased demand is being met almost entirely from within the country. With the increasing population, this demand will continue to grow, so that there is to-day a greater need than ever for efficient utilization. This has focused attention on the large amount of waste associated with present practice because of the characteristics of our forests and timbers. Taking into account trees and portions of trees which are left behind in the bush for various reasons, sawmill losses in sawdust and edgings, and further losses in the re-manufacturing of timber, it is estimated that on the average only 10 per cent. of the timber we grow is utilized in its final form. Some of the waste is used for fuel, but most of it is at present a liability rather than an asset. The Division has therefore given special attention to this problem of waste.

It is obvious that the problem as a whole will not be solved until much more knowledge is assembled of the basic chemical, physical, and mechanical properties of our woods. The ultimate solution would then seem to lie in a greater integration of wood-using industries. Some progress has been made by the industry but full development must await further research.

Two important overseas conferences were attended by an officer of the Division. The first was a meeting of the Sub-committee on Mechanical Wood Technology of the Food and Agricultural Organization held in Geneva. The second was held at the Forest Products Laboratory, Ottawa, Canada, and subsequently completed at the Forest Products Laboratory, Madison, Wisconsin, United States of America.

In Australia, the Annual Forest Products Research Conference was this year held at the Division of Wood Technology, New South Wales Forestry Commission, Sydney, to co-ordinate programmes of research.

There has been a further increase in the number of inquiries handled by the Division. Over 4,000 requests for information were received in addition to those covered by correspondence.

A seasoning class consisting of one week's lectures and practical work was held in Adelaide, South Australia, with the co-operation of the Timber Development Association. An innovation during the year was a course of eight evening lectures on timber seasoning which was given to members of the Victorian Sawmillers' Association and Timber Merchants' Association.

Three liaison officers of the Commonwealth Department of Works and Housing were given a special course in forest products. The courses for forestry and engineering students at the University of Melbourne were continued and, in addition, a special course of ten lectures on timber was commenced for architectural students. Thirty-three students from the Australian Forestry School, Canberra, spent approximately two weeks at the Division. Evening lectures included talks to the Australian Pulp and Paper Industry Technical Association, branches of the Building Workers' Industrial Union, church societies, and others.

The Division, in association with the Building Research Section, prepared an important exhibit for the Australian Industrial Fair held at the Exhibition Building, Melbourne. Exhibits were also provided in conjunction with the "Save the Forests" campaign at the Royal Agricultural Show, Melbourne, and at the Agricultural Show, Ballarat.

The co-operative research scheme with the paper companies has continued to function smoothly and effectively during the year. In addition, the co-operation and help of the Commonwealth Forestry and Timber Bureau, the various State Forest Services, and the New Guinea Forests Department are gratefully acknowledged.

It is pleasing to note the increasing number of overseas visitors to the Division.

2. WOOD STRUCTURE.

(*a*) *Wood Anatomy.*—The study of the anatomical details of the timbers of Australia and neighbouring areas is important not only for timber identification but also for classification and the development of a greater knowledge of their properties. During the past year the work has been greatly assisted by the addition to the standard collection of authentic specimens from New Guinea, British North Borneo, and the Northern Territory of Australia.

Work has been completed on the timbers of the Anonaceae and practically completed on timbers of the Myrtaceae. Revision of the methods of identification of eucalypt timbers is in hand and it is hoped eventually to provide a card sorting key for these timbers based on microscopic features.

(*b*) *Cell-wall and Fibre Studies.*—(i) *Cell-wall Organization.*—There is more and more evidence that timber properties depend to a considerable degree on the cell-wall organization, and therefore the study of the cell-wall in relation to properties is an essential feature of the work of this Section. Recent investigations have been concerned with the compression wood in *Pinus radiata* D.Don. It has been found that the compression wood tracheids are appreciably shorter than would be expected for normal wood in a comparable position in the tree. From the aspect of cell-wall organization, however, it would appear that such compression wood tracheids are essentially similar to normal wood tracheids of the same length although differing in chemical composition. Confirmation of the cell-wall organization of conifer tracheids as deduced from optical investigations has been obtained from electron micrographs. In this work, carried out in co-operation with the Division of Industrial Chemistry, it was shown that the fibrillar orientation of the inner layer of the secondary wall was in a relatively flat spiral in relation to the major fibre axis. Confirmatory evidence was also obtained of the steep fibrillar spiral of the middle layer of the secondary wall.

(ii) *Fibre Length Variation.*—It has been established that there is considerable variation in fibre length within one growth ring of *Eucalyptus gigantea* Hook.f. and other eucalypts with equally prominent growth rings. The shortest fibres were found in the first-formed early wood and the longest, approximately 50 per cent. longer, in the last-formed late wood. In all hardwoods with definite growth rings a considerable variation in length within one growth ring was found. With hardwoods growing under tropical conditions no great variation in fibre length was evident. Preliminary work with a number of coniferous timbers has indicated that late wood tracheids are slightly but insignificantly longer than early wood tracheids.

(*c*) *Structure in relation to Properties.*—(i) *Sapwood-heartwood.*—It was found that conditions responsible for the development of tyloses in woods with large vessel-ray pitting were also responsible for the secretion of gum in woods with small vessel-ray pitting. Both tyloses and gum are always developed from the ray cells. A technique has now been developed for examining the living content of such cells in material specially fixed immediately after felling. Results have indicated that timbers may fall into three classes. In the first, the ray cells remain alive a very long time and starch may be found at the centre of very large trees. In the second group, the ray cells may remain alive a long time but there appears to be a progressive death of the cells starting at the periphery and increasing further in. In these woods it seems as if there comes a time when insufficient living cells are left to keep the tissue alive and the change from sapwood to heartwood then takes place. In the third group the ray cells remain alive for only a short period. Here there is a narrow sapwood and a comparatively sudden death of the cells at heartwood formation.

(ii) *Brittle Heart.*—In co-operation with the Section of Timber Mechanics conditions relative to the formation of fibre failures in normal timber have been investigated. In this connexion examinations have been made of many hundreds of specimens of mountain ash, grey ironbark, and hoop pine which had been subjected to varying degrees of compression with the object of inducing fibre failures. In other experiments the development of fibre failures on the compression side of beams subjected to loading for various periods of time has been followed.

(iii) *Collapse.*—The extent and rate of development of collapse in the early and late wood of *Eucalyptus regnans* has been studied. Collapse develops very rapidly in early wood.

(*d*) *Identifications and Identification Methods.*—The identifications from various sources have totalled 600, not including the many New Guinea and Northern Territory specimens which were examined and classified tentatively to assist botanical determinations. One hundred sets of the card sorting key for commercial Australian timbers have now been made up and some preliminary distributions made.

(*e*) *Growth Studies.*—(i) *Eucalyptus gigantea.*—Within any one growth ring of this species the fibres were shortest where the growth rate was at a maximum; these conditions occurred just after the beginning of the early wood formation. The radial diameter of fibres also varied within the growth ring, the short early-wood fibres being of greater diameter than the longer late-wood fibres. The difference in fibre length within a growth ring is accommodated by the variation in fibre overlap.

(ii) *Queensland Species.*—The types of tissue laid down by *Beilschmiedia bancroftii* C. T. White at different times of the year have been examined. This species is characterized by the presence of concentric bands of parenchyma and it has been established that the production of this tissue is not related to the season of the year.

(*f*) *Siliceous Inclusions in Timber.*—A survey of timbers occurring in the south-west Pacific area, to determine the nature and extent of siliceous inclusions, has been completed. In addition, timbers from other parts of the world have been examined and the literature on the subject of silica in timber reviewed. From this survey approximately 400 timbers belonging to 30 families have been found to contain silica and the actual amount present in the majority has been determined. Silica occurs in the form of corpuscular aggregates when the silica content of the timber, based on the dry weight, exceeds 0.05 per cent. The presence of silica is related not only to the resistance of certain timbers to attack by shipworms but also to the working qualities of timber.

3. WOOD CHEMISTRY.

(*a*) *Lignin and Related Compounds.*—(i) *Methanol Extractions of Lignin.*—Methanol extractions at 150° C. of young *Eucalyptus regnans* F.v.M. sawdust have shown that about 87 per cent. of the original Klason lignin is removed during the course of a 500-hour extraction. It is possible to extract nearly all of the lignin in a finite time. Thus there is no evidence for the existence of a lignin fraction resistant to the action of methanol at 150° C.

(ii) *Aldehydes from Eucalypt Lignins.*—Twelve species of eucalypt wood have now been subjected to nitrobenzene oxidation and the resulting aldehydes isolated and examined. Separation by vacuum sublimation indicated considerable variation in the ratio of syringaldehyde to vanillin, ranging from 1½ : 1 to 5 : 1. A method for the separation of vanillin and syringaldehyde by paper partition chromatography has been developed.

(iii) *Determination of Hydroxyl Groups.*—A method consisting of acetylation of the compound with a mixture of acetic anhydride and pyridine and determination of the excess acetic anhydride by electrometric titration has been used. The acetylation is carried out in small sealed tubes which are crushed under water.

(iv) *Periodate Lignin.*—Specimens of periodate lignin have been prepared from *E. regnans* by the method of Ritchie and Purves. The highest apparent Klason lignin content so far achieved is 76 per cent.

(*b*) *Wood Carbohydrates.*—(i) *Fractionation of Wood Nitrates.*—Ten samples of nitrated wood carbohydrates and cotton celluloses have been fractionated and 200 fractions obtained. Since the viscosity of a given cellulose chain varies with the degree of esterification, nitrogen determinations are being made on all samples. A modified and semi-automatic micro-Dumas method is being used.

(ii) *Alkaline Degradation of Holocellulose.*—Some further work related to the behaviour of holocellulose and of cotton on treatment with very dilute alkali at room temperatures has been carried out. Because of the probability of collapse of the acid-swollen fibres on drying from water, the experiment with cotton has been repeated with linters swollen in cold 12 per cent. alkali, which were then neutralized, washed, and chlorinated without at any time being allowed to dry. Even these linters of high accessibility showed no major breakdown on treatment with dilute alkali, which confirms that this effect is not merely the breakdown of β-glycosidic links rendered alkali-sensitive by oxidation with chlorine, but is due to some special linkage found in the wood.

(*c*) *General Wood Chemistry.*—(i) *Chemical Investigations into the Cambial and Neighbouring Zones in E. regnans.*—The Klason lignin content and the methoxyl contents of Klason lignins, of the oven-dried, air-dried, and 80 per cent. ethanol extracted samples from the various zones indicate that the method of drying used in the preparation of samples is important. The cambial zone is comparatively rich in nitrogenous materials, containing approximately 13 and 1 per cent. of protein and nitrate respectively. The differentiated wood tissues contain small amounts of nitrogenous materials, whereas the other zones contain 2 or 3 per cent. of protein. The sugar distribution is similar to that of the proteins.

(ii) *The Hemicelluloses and their Association with Lignin.*—Methanol cooks at 150° C. have been carried out on a sample of *E. regnans* sawdust which had previously been treated with cold 5 per cent. sodium hydroxide solution. The results indicate that the cold alkali solution, in addition to removing all or most of the non-resistant "polyaldo-uronide", removes a portion of the resistant hemicelluloses and so modifies a further portion of the resistant hemicelluloses that they become soluble during a subsequent "holocellulose" determination. However, the cold alkali removes only about 8 per cent. of the original lignin.

(iii) *Relationship between Chemical Composition and Grinding Properties of Eucalypt Wood.*—The only marked difference that has been found is that samples of poor grinding wood had holocellulose contents of 80-83 per cent., but good grinding samples contained about 72 per cent. The latter value is rather low for *E. regnans*. The good grinding wood came from old trees (over 250 years old).

(*d*) *Wood Hydrolysis.*—*E. regnans* wood and its holocellulose have been hydrolysed for varying periods of time at 92°C. with normal sulphuric acid. After hydrolysis of the wood for certain times which are dependent on the temperatures the residue is such that practically no hydrolysis proceeds although it contains cellulose.

(*e*) *Extractives of Wood.*—(i) *Kino of Jarrah.*—One unexamined source of tannin is the kino-like substance in jarrah (*Eucalyptus marginata* Sm.), which exists as accretions in the cells to the extent of 25-30 per cent. of the timber. Its extraction is being studied. A fractionation procedure has been developed which enables the kino of *E. calophylla* to be separated into a colourless crystalline compound (5 per cent.), a blood-red pigment (20 per cent.), and a brown coloured tannin. *E. corymbosa* kino also contains this colourless compound.

(ii) *Colouring Materials in E. regnans Wood.*—This investigation is being carried out at the Chemistry Department, University of Western Australia. It has been demonstrated that methanol is a suitable solvent for the substances producing a pink colouration in some samples of *E. regnans*. Chromatographic absorption on alumina and magnesium carbonate has resulted in a separation of the material giving rise to the dark red colour of the extract.

(*f*) *Pulp and Paper Investigations.*—(i) *Influence of Electrolytes.*—A systematic survey of the effect of increasing concentrations of cations on pulp and paper properties was completed. This confirmed previous work which had indicated that those of the highest valency had the most marked effect. Anions do not influence pulp and paper properties in the same manner as cations, the only effects observed being due to the metallic ion.

(ii) *Addition of Amino-resins to Pulps.*—Investigations have been made into the use of urea-formaldehyde and melamine-formaldehyde resins for increasing the wet strength of paper. The work has revealed that eucalypt pulps are not as amenable to wet strength development by means of resins as are long-fibred pulps.

(iii) *Inspection and Testing.*—British standard pulp evaluation equipment being manufactured in Australia under licence from the Technical Section of the Paper Makers' Association of Great Britain and Ireland has been inspected and tested. Australian-made dynamic tear testers have been inspected and calibrated.

Correlation studies of paper testing instruments have been undertaken in co-operation with the Australian pulp and paper industry, and further work on the reasons for variations has been carried out.

(iv) *High Alpha Pulps from Jarrah.*—The low pentosan content of jarrah makes it more suitable than most eucalypts for the production of high alpha pulps. Alkaline pulping methods which have been employed in Australian pulping procedures will produce a pulp from jarrah but the chemical consumption is very high because of the large amounts of extraneous materials. The use of ammonium bisulphite as a cooking liquor has been found to produce pulps which defibre readily and which have a chemical consumption similar to that for softwoods.

4. TIMBER PHYSICS.

(*a*) *Physical Properties of Wood.*—Density and shrinkage studies have been extended to cover timbers of the whole of the South-west Pacific region. Shrinkage determinations have been made on both soft and hard fibre-based wallboards. The variation of shrinkage throughout the tree is being studied. Species corrections for a number of Australian, New Guinea, and Sarawak timbers have been determined for use with electrical moisture meters. The effect of temperature on the tensile strength of mountain ash perpendicular to the grain, together with the strain at maximum load, is being investigated, as well as the effect of temperature and moisture content on the strength of wallboards over a wide range of humidities for temperatures between 0° C. and 80° C.

Equipment has been improved, and is now being used for the determination of the thermal diffusivity and conductivity and the specific heat of wood and fibre-based wallboards at various temperatures and humidities. Work has also been commenced on the determination of the co-efficient of thermal expansion of wallboards.

A comprehensive series of tests on mountain ash has been commenced to determine the variation of the dielectric properties with direction of grain, moisture content, temperature, and frequency.

(*b*) *Studies of Creep in Wood.*—Recovery tests on initially green beams have shown that at least half of the increased deflection due to long-time loading is recoverable and a few dry beams gave similar results. Air-dry beams under load for more than a year have reached deflections of about three times the initial value. The decrease in the length of the compression face of wooden beams under prolonged loading is consistently greater (1.5 to 3 times) than the increase in length of the tension face. The strain rate of beams fluctuates with atmospheric temperature and is very noticeable as an increase in strain rate during the day and a decrease during the night. So far, all attempts to find a stress below which plastic flow in initially green beams does not occur have proved unsuccessful and the limit, if it exists, cannot be more than 1 or 2 per cent. of the ultimate strength when green. Work has been commenced on creep in small beams consisting wholly of reaction wood. Mountain ash tension specimens at 14 per cent. moisture content and 35° C. have been tested under prolonged loading at 1,000, 2,000, 3,000 and 5,000 lb./sq. in. The proportional increase in strain does not appear to be nearly as great as for beams, nor does it continue for so long.

Tensile specimens after a period of prolonged loading sometimes show greater recovery than for beams, in some cases 70 to 85 per cent. of the strain due to long-time loading being recoverable. A few trial shear tests showed a marked decrease in shearing strength under prolonged loading.

(*c*) *Electrical Strain Gauges.*—The use of the 48 channel unit is being studied in co-operation with th Timber Mechanics Section. A methyl methacryli ester was found which, although not entirely water proof, is superior to cellulose nitrate for gluing gauge to timber. The behaviour of electrical resistanc strain gauges for use in creep tests has been furthe studied and in spite of some zero gauge fluctuation they appear to have possibilities in long-time loadin tests.

(*d*) *Battery Separators.*—Tests on likely timber from the South-west Pacific area have been continued More extensive life tests both with and without vibration have been carried out on klinki pine, a New Guinea timber, the results showing that this species is suitable for use in separator manufacture. Life testing of separators of promising Australian species is being undertaken. Following on the work of the Division the Standards Association of Australia issued a draft specification for wooden battery separators and discussions based on comment on this draft have been completed.

(*e*) *Other Investigations.*—A 50-watt ultrasonic generator has been constructed and is being used to study problems connected with wood processing, such as energy transfer to suitable liquids.

5. TIMBER MECHANICS.

(*a*) *Studies of Mechanical Properties and Testing Methods.*—The two international conferences held overseas last year have had important effects on the outlook as well as on the detailed test procedure of the Section A recommendation of the Geneva conference was that further study should be made of a number of important subjects and the question of the general requirements of tests, covering accuracy, standard conditions of moisture content and temperature, the presentation of data, and so on, was assigned to the officer-in-charge of this Section. Many of the detailed recommendations of the conferences have been put into practice in the laboratory, one of the most important being the decision that testing generally should be carried out at a constant rate of cross-head movement. The testing machines in this laboratory are mostly equipped for operation at a constant rate of load application and it has been shown that considerable differences in test results may arise from the difference in technique. It is proposed, therefore, to fit strain pacers to the machines. In the meantime, improvisation has allowed the change in technique to be made.

Another important procedure confirmed at the conference at Ottawa and Madison was that for adjusting air-dry test figures to the standard moisture content of 12 per cent. Other laboratories in English-speaking countries use an intersection point obtained from the relationship between strength and moisture content, but in this laboratory an intersection point obtained from the relationship between shrinkage and moisture content has always been used. Provided the correction is not large, the difference in procedure is not material, but a few species—mountain ash and karri for example—show abnormally high shrinkage intersection points and the difference, or error, becomes appreciable. Consequently an investigation has been started of the effect of moisture content on the elastic and strength properties of certain species, while the Section of Timber Physics will investigate the more general problem of the differences between intersection points obtained by different methods.

Because of the differences in properties of the early and late wood the properties of a specimen of timber will be expected to vary with its chance positioning with relation to the rings. A study has been made of the relative contribution of the rings to stiffness and strength and it has been shown that the effect on variability will be appreciable when the number of rings is small. This effect would be important if small specimens were taken from fast-grown material.

(*b*) *Species Testing.*—As there are probably several hundred species in Australia which it would be worth while testing, and as the present test rate is such that very many years would be thus occupied, the selection procedure has been investigated to seek improvement. It has been found, most strikingly, that selection is more efficient when a few test specimens are taken from each of a large number of trees rather than a large number of specimens from each of a few trees. This plan has been put into operation as a trial on one species chosen from each group. During the year tests were carried out on several Australian species and a number of species from New Guinea, Borneo, and New Zealand.

(*c*) *Silvicultural Tests.*—In testing small size thinnings from forests under silvicultural management it has been realized that the usual style of test piece, while adequate for evaluation of the properties of the thinnings, is much too large to be useful in determining the effects of various treatments on the properties of the timber laid down subsequently. A microtensile machine to take very thin specimens has been made.

(*d*) *Long-time Tests.*—The connector tests set up under tensile loads some years ago have not failed by splitting of the members as occurred in practice nine to twelve months after construction, but recently two mountain ash joints erected in 1945 have failed by the splitting out of the central member.

(*e*) *Growth Stresses in Trees.*—A study has been commenced of the stresses in growing trees which evidence themselves in the "popping" of logs when cross-cut, in spring when logs are ripped, and in heart shakes and compression failures in mature standing timber. They are of economic importance to the plywood manufacturer as well as to the saw-miller. The stresses can conveniently be regarded as acting in the longitudinal, radial, and tangential directions. In the eucalypts, to which the study has so far been confined, the radial stresses are not serious in their effects. The ring or circumferential stresses are compressive at the periphery and tensile, and increasing in intensity, toward the pith; usually they are not critical. The longitudinal stresses are tensile at the periphery and compressive and cumulative toward the heart; the tensile stresses appear to be about 1,500 lb./sq. in., and the compressive values theoretically may mount far beyond the maximum compressive stresses determined in standard laboratory tests. They are the probable cause of the formation of "brittle heart". Laboratory tests are being carried out to stimulate the production of brittle heart. When a tree is cross-cut, the longitudinal stresses are released at the cross-cut face and there is an appreciable tensile effect in the transverse plane which, added to the tensile ring stress, is sufficient in many instances (perhaps always in the eucalypts) to cause heart checking.

(*f*) *Containers.*—Early in the year an officer of the Division of Wood Technology, New South Wales Forestry Commission, was trained in box testing technique and the equipment was then sent to Sydney on loan to that Division.

Many industries have benefited from the advice of the Division during the year. Perhaps the most unusual commodity container handled was a radio-isotope box which was redesigned, with a substantial reduction in weight, for air freight between the United States and Australia.

(*g*) *Other Investigations.*—Assistance has been given to the Preservation Section in the design of a 1,000-lb./sq. in. cylinder for impregnation of eucalypts with preservative. No suitable commercial equipment was available and many problems have had to be overcome.

6. TIMBER SEASONING.

(*a*) *Moisture Equilibrium Studies.*—A knowledge of the range of dimensional change that occurs in seasoned timber with change in weather conditions is of considerable importance. This relationship has, in the past, been determined by the actual exposure of sample timbers at particular sites. An examination has been commenced to determine the relationship between meteorological data and equilibrium moisture content. Equilibrium moisture content values can be expressed as a function largely of current and past relative humidities. By applying this method to data from some 200 meteorological stations throughout Australia, maps showing lines joining sites of identical equilibrium moisture content have been prepared for two species.

(*b*) *Veneer Drying.*—Much attractive and potentially valuable veneer may be peeled from the "ash" type eucalypts. The development of an extensive plywood industry in south-east Australia based on this material is, however, at present severely handicapped by industry's lack of ability to season this stock satisfactorily. Laboratory work has now shown that the primary cause of degrade during drying is collapse which acts differentially between early wood and late wood; further, that the magnitude of collapse is chiefly a function of the wet bulb temperature and is independent of the dry bulb temperature. Checking is at a minimum at a wet bulb temperature of 110° F., but increases with drying time so that an elevated dry bulb temperature for rapid drying is desirable. Peeling technique influences drying behaviour and reconditioning results in a 6 to 12 per cent. recovery in width, and the virtual removal of buckling and wrinkling.

(*c*) *Kiln Drying.*—Although available in quantity, a number of the "stringybark" eucalypts of south-eastern Australia have been little used for joinery purposes because of their refractory seasoning characteristics. Laboratory seasoning studies of these species were commenced, those on brown stringybark (2-inch thick backsawn), white stringybark (1-inch and 2-inch thick backsawn and quartersawn), and silver-top ash (1-inch thick backsawn), being completed during the year. From the studies made, schedules have been developed which will give seasoned stock of satisfactory quality. For the backsawn stock particularly, a chemical pre-treatment with sodium chloride was found of considerable value in reducing degrade from checking. Work on the development of drying schedules for klinki pine and ramin (*Gonystylus* sp.) was commenced. An examination of the drying behaviour of 1-inch thick myrtle-beech and alpine ash was also completed for the study of these timbers under pre-drier conditions.

(*d*) *Drier Design and Layout.*—Requests by industry for assistance in the development of seasoning plant and equipment were heavy throughout the year. Designs in a wide range covering timber seasoning kilns, veneer driers, and drying rooms were prepared for some 40 companies. Approximately 350 drawings with appropriate specifications and material lists were issued. Examinations of site conditions and facilities available to a number of processing plants were also made in South Australia, New South Wales, and Tasmania, and suitable lay-out plans were prepared. Inquiries for advice on the design of wood-waste disposal units, capable of effective operation without involving fire hazard, were numerous. Some 70 drawings were issued. An analysis of the performance of a timber pre-drier, to provide accelerated pre-kiln-drying in areas subject to poor air drying weather, was completed. A prototype is operating successfully but modifications in design are being provided to reduce static head through the system, circulation losses, and construction costs. Designs for units to hold up to 300,000 super. feet per charge are being prepared.

Methods of drying sawdust, as a pre-requisite to the manufacture of wood flour, were examined. A towered drum system appears the most effective for the particular installation and designs are being prepared.

(*e*) *Studies in Saw-mill Performance.*—An analysis of saw-mill efficiency was made from field data obtained during production and time studies previously carried out on saw-mills operating in Western Australia. In particular, studies of the effect of log girth on a number of production variables were made. A visual examination of the effect of mill lay-out on the pattern of timber flow was also carried out to determine points of inefficiency. Studies of a portable mill of new design, operating as a log edger for the conversion of logs up to 22 inches in diameter, were carried out.

(*f*) *Building Materials.*—Progress was made in the study of factors affecting the mechanical and physical properties of sawdust-synthetic resin combinations. With the resin examined, satisfactory dimensional stability and bending strength (comparable with a good quality hardboard) is obtainable with a medium grade sawdust (14-22 mesh) in association with a finely ground resin, when pressed at a temperature of approximately 400° F. and a pressure of approximately 500 lb. per square inch for a period of ten to twelve minutes. Under these conditions fully cured material has a density approximating 60 lb. per cubic foot.

Work on the use and suitability of sawdust-cement and wood-wool cement combinations as flooring and wall slab materials was confined to advice to industry and the general public.

(*g*) *Other Investigations.*—A pilot plant was built to study the suitability of vapour drying for Australian timbers. Drying of joinery stock as well as sleepers prior to preservative treatment will be investigated. Miscellaneous subjects on which information was sought included the drying of plaster sheet, the drying of rabbit skins, vacuum drying, chemical seasoning, high frequency seasoning, radiant heating, heating with high-pressure hot water, kiln drying schedules, timber handling, wood-wool production and drying, moisture meters, working and shrinkage of timber, heat transfer in timber, calorific values of wood, kiln maintenance, kiln drying costs, collapse and reconditioning, kiln instruments and operation, the utilization of wool waste, temperature and humidity control equipment.

During the year twelve students from industry completed one of the correspondence courses in timber seasoning and kiln operation conducted by the Division.

7. Timber Preservation.

(*a*) *Field Tests.*—Four field tests have been examined in New South Wales, Victoria, and South Australia. In South Australia the performance of treated *Pinus radiata* sleepers and poles installed in 1936 is now arousing considerable interest. There are approximately 1,300 sleepers in test representing various pressure treatments of *P. radiata*, the performance of which is being compared directly with that of untreated red gum and jarrah sleepers. The test is installed in six localities representing light to heavy traffic densities and ranging from wet conditions near Mount Gambier to arid sites on the Broken Hill line near Peterborough. *P. radiata* sleepers pressure-treated with oil preservatives, particularly a mixture of creosote and petroleum oil, are performing excellently and in most sections, after twelve years' service, appear likely to give a longer life than untreated eucalypt sleepers. As these treated pine sleepers were cut from relatively small diameter trees, the test has already demonstrated the potential importance of plantation-grown P. *radiata* as a substitute for durable eucalypt sleepers now in increasing short supply. Treated *P. radiata* telephone poles in test within a 50-mile radius of Adelaide are also yielding promising results as full length open tank treated poles are still in excellent condition and give promise of a long service life. As a direct result of this test it now appears likely that a market for treated *P. radiata* poles will be opened next year in South Australia. Other field test work has included the inspection of variously treated timbers exposed to termite attack near Canberra, and to decay attack near Melbourne, and also the retreatment of lower durability eucalypt sleepers in test between Melbourne and Albury to determine the effect of surface coating with preservative oils. (*See* also work in the Division of Entomology, Chapter IX., Section 12.)

(*b*) *High-pressure Treatment of Eucalypt Timbers.*—The results of a reconnaissance of the treatability of 47 Australian timbers have been most promising and have indicated that at pressures up to 1,000 lb./sq. in. the majority of eucalypt timbers can be penetrated reasonably well with creosote oil.

(*c*) *Lyctus Investigations.*—During the year a new and simple method of treating veneer against borer attack was released to industry. This new method involves only the momentary immersion of green veneer in cold solutions of either boric acid or borax, followed by block stacking of the treated sheets for a few hours before drying. Treated timber has proved completely immune to attack and this simple method, which greatly accelerates the rate of treatment at a fraction of the previous cost, has already been adopted by many commercial plants.

A second possible method of preventing attack in plywood made from susceptible veneer is still under test. In this method the effect of adding various toxic chemicals to glues used for bonding plywood is being determined. Results after two and a half years are promising for some chemicals, particularly "Gammexane", which has completely prevented attack even at low concentrations. However, this test must continue for some years yet until final conclusions can be drawn.

In co-operation with the Division of Entomology, Canberra (*see* Chapter IX., Section 13 (*d*)), studies have been commenced to determine the nutritional requirements of *Lyctus brunneus*. Small wood specimens have been extracted to remove natural starch and other nutriments, and then re-impregnated with starch, sugar, protein, and minerals.

(*d*) *Metallic Naphthenate Preservatives.*—A study to examine variations in the chemical composition, toxicity, and permanence of metallic naphthenates prepared from crudes of different oil field origins is now in progress to form the basis for a specification for metallic naphthenates for use as wood preservatives. An efficient fractionating column has been constructed, methods of toxicity testing have been investigated and standardized, suitable test fungi have been selected, and the toxicity of various solvents has been studied.

(*e*) *Preservative Treatment of Cross-arms.*—Surveys to determine causes of failure have been completed in Western Australia and Victoria and preliminary tests made to determine whether cold soaking treatment in light oil preservatives will give sufficient penetration in pre-bored arms to retard the main types deterioration revealed by the surveys. This work is of considerable potential importance as cross-arms are used without treatment throughout Australia and any method of prolonging the life of the many millions in service will result in an appreciable saving of high-grade timber. Both the Postmaster-General's Department and the State Electricity Commission of Victoria are co-operating in this work.

(*f*) *Timber Mycology.*—A comprehensive test has been commenced to determine the relative durability to decay of approximately 100 of the principal Australian timbers, using an accelerated laboratory technique. The work has been planned so that termite durability may be studied on matched material by the Division of Entomology, Canberra. Work has been commenced to determine whether durability of eucalypt timbers is related to the presence of toxic materials in the wood or due to other factors.

(*g*) *Other Investigations.*—Diffusion studies have continued during the year to determine factors governing the rate of diffusion of salts into green timber. The effect of temperature on diffusion rate has been re-examined and the correlation between the temperature coefficient and the diffusion constant used as a basis for theoretical characterization of the number and size of capillaries in the diffusion path. A co-operative test is being arranged with the D.S.I.R. (New Zealand) to determine the susceptibility of *P. radiata* to the Anobium borer.

Work on protective coatings for wood stave pipe in Western Australia has now been completed and recommendations made for the field testing of the most promising coatings.

8. VENEER AND GLUING.

(*a*) *Veneer Cutting and Drying.*—(i) *Plantation-grown Pines.*—Veneers over a range of thicknesses from 0.0075 inch to 0.5 inch were cut from logs of radiata pine. No difficulty was experienced in cutting and drying veneer of any thickness within this range and it is considered that good supplies of veneers suitable for plywood and other veneer products should be available from plantations provided these are managed for the production of suitable logs as regards both quality and size. Uses for veneers of various thicknesses are under investigation. Further logs of slash and loblolly pines were cut into veneers as part of a continuing investigation to determine policy in the silvicultural treatment of plantations of these species in Queensland.

(ii) *Ash Eucalypts.*—Studies on the ash eucalypts as veneer and plywood species have continued with alpine ash as the chief species under observation.

(iii) *Heating of Veneer Logs.*—Data are being collected on schedules for heating veneer blocks in water to obtain best results from veneer cutting and drying.

(iv) *Lathe Manufacture and Design.*—Assistance was given to four firms actively engaged in the manufacture of veneer lathes and the force necessary to drive lathe dogs into peeling blocks was investigated experimentally in conjunction with the Timber Mechanics Section.

(*b*) *Gluing Investigations.*—(i) *Survey of Gluing Properties.*—A number of Australian woods have been glued with different adhesives and the strength of the joints tested to determine their gluing characteristics and suitability for plywood and other glued wood assemblies. Similar investigations were made on a wood fibre board.

(ii) *Adhesives.*—The possibility of using the following adhesives for gluing assemblies of wood or veneer was investigated: starch, peanut meal, safflower meal, soya bean meal, rennet and acid caseins, lignin-furfural, urea-formaldehyde, phenol-formaldehyde, melamine-formaldehyde, and various mixtures of the above. Most of these were studied as a result of shortages of lactic casein supplies to the plywood industry. Samples of acid casein from trial batches produced by a dairy produce organization contemplating regular production of acid casein are being tested for adhesive properties. Acid casein is used overseas for adhesives but up to now has not been produced commercially in Australia. If current trials are successful acid casein might become a major adhesive in the Australian plywood industry. A number of industrial gluing problems, including staining of plywood faces, blistering of fancy plywood, and various assembly gluing failures with all types of glues in common use in Australia, was studied. Laboratory work was carried out to determine the effect of glue strength factors such as glue room temperature, age of glue mix, and assembly time. Assistance was given to three firms engaged in the manufacture of laminated tennis racquets.

The wet strength of joints between borax or boric acid treated veneers glued with a phenolic film adhesive and the nature of the factors causing deterioration are being investigated.

(*c*) *Mechanism of Setting of Glues and the Nature of their Adhesion to Wood.*—Some proteins, in concentrated alkaline solution, are able to form rigid gels, and although this phenomenon has industrial applications in gluing wood and in other fields, its mechanism has hitherto received little study. However, arising out of rheological studies on the changes in viscosity and yield value of various adhesive systems during the course of their working life, a major investigation has been initiated into the basic nature of the molecular associations leading to gelation in casein-alkali systems. That casein is not a homogeneous protein has been recognized for some time, and this has been confirmed for the lactic casein used in these experiments by the preparation of fractions over a range of pH and the demonstration that they possess different properties. It appears from viscosity studies that the differences in weight and shape of the molecules presented in the fractions are small, and that differences in solubility, colour and their behaviour in glues must be assigned primarily to chemical variations. In studying the gelation process, principal attention has been focused on the system casein-sodium hydroxide-water. The overall process has been observed to be exothermic and the rise in temperature with time has been measured. The rheological behaviour has been examined over a wide range of pH, and striking differences observed in such properties as initial viscosity and rate of viscosity increase. Gelation is confined to a fairly narrow pH range, above which the process is disrupted by protein hydrolysis. A study has been made of the properties of protein reprecipitated from systems of various pH, with the object of correlating the degree of denaturation with the rheological behaviour. Criteria so far examined include macroscopic appearance, intrinsic viscosity in phosphate buffer, optical rotation, light absorption, and refractive index of the solutions at constant concentration, and exposure of the sulphydryl group of cysteine.

These investigations open up practical possibilities in the development of other proteins as alkaline glues, in the study of protein plastics and fibres, in their relation to industrial problems concerned with different methods of precipitating casein from skim milk and the utilization of the various products obtained.

(*d*) *Plywood.*—Dry veneers of various species were glued into small plywood sheets using hot and cold setting glues to determine possible commercial performance and industrial applications. Studies of the nature of frequency distribution of failing loads in glue shear tests on plywood were made with a view to permitting better interpretation of results of laboratory tests of gluing properties of different veneers and a comparison of different adhesives for plywood manufacture. Accelerated exposure tests were used to determine the serviceability of veneers of different thicknesses as face plies and relative weathering properties. Various exposure tests were conducted to determine the water resistance of plywood glues and to compare the weather resistance of face veneers of different species in different thicknesses, and the effects of using various surface coatings. Thin veneers were found most satisfactory and certain surface coatings considerably increased resistance to weathering.

(*e*) *Industrial Assistance.*—Important items on which advice and assistance were provided included the layout of plywood plants, operation of plywood manufacturing machinery, future requirements of plywood adhesives, adhesives for specialty purposes, flush doors, use of plywood for housing, boats, and other constructions.

9. TIMBER UTILIZATION.

(*a*) *Timber Uses.*—Many requests for information and assistance with problems connected with timber utilization were received during the year from the timber industry, governmental and semi-governmental organizations, and private individuals. Information was supplied on the suitability of various timbers for the following uses:—Acid containers, agricultural machinery, agricultural seed boxes, archery bows, bee boxes, battery boxes, bench tops, billiard cues, blind rollers, boot and shoe lasts, bowling pins and bedstocks, boat building, butter boxes, butter churns, butchers' blocks, cable boxes, clock cases, clothes pegs, clutch blocks, croquet mallets, drawing boards, electrical transformers, fence posts, floats, flooring, framing timbers, gear teeth, golf club heads, handles, ice-cream spoons, insulator spindles, log cabins, matches, motor bodies, parquetry flooring, piles, pump rods, printers' blocks, refrigerator framing, rowing skiffs, rubbing blocks, rules, scantling, sense aid equipment, skis, smokers' pipes, spring boards, stumps, surf boards, shingles, textile rollers, vats, venetian blinds, violin bows, water cooling towers, wedges, wringer bearings. A survey of wooden tanks in industry was completed and has revealed information on the timbers giving satisfactory service under variable conditions. Water cooling towers of various ages were inspected to determine the location and major causes of breakdown in the range of timbers used. Notes were prepared for industrial contacts on the properties and uses of seventeen Australian and eight New Guinea and northern hemisphere species.

(*b*) *Manufacturing Processes.*—Sawmill layouts and details on characteristics of equipment were supplied to operators contemplating improvements to or the establishment of mills in forest areas in various parts of Australia and detailed plans were prepared where required. Features of efficient sawing units, such as log edgers and sawbenches with modern feeding devices, were published in an endeavour to widen their application. The requirements for manufacturing wood flour and wood wool were set out in detail for several inquirers. The survey of power requirements of woodworking machinery was continued and as part of this project a mill study was undertaken to determine the productive capacity of band resaws in a large box-making plant. Details on manufacturing techniques to improve quantity and quality production were given for a number of products.

(*c*) *Waste Utilization.*—Investigations continued of the factors influencing the quality of pulp produced from *Pinus radiata* and *Eucalyptus regnans* chips in an attrition mill and the properties of boards produced from such pulps by hot pressing. A series of temperatures, pressures, and durations of pressure have been used in tests aiming to show the effect of pressing conditions on strength of boards. Several inquiries relative to the equipment used in the commercial scale fibre board industry were dealt with. Numerous inquiries on sawdust and waste utilization were received and advice was given, particularly on the economic aspects of the problems.

(*d*) *Sawing Studies.*—Equipment was designed and partly completed during the year to permit study of the action of a single sawtooth and the energy consumed in cutting, and of fundamentals of the cutting and grinding of wood. Investigations on chain saws were continued in the laboratory and the field, information gathered on factors affecting their operation and maintenance, and assistance given to a company commencing manufacture of these machines in Australia.

(*e*) *Standards.*—Collaboration with the Standards Association of Australia was continued on all matters pertaining to timber standards. A Timber Industry Committee was formed in September, 1948, and the Chief of the Division was installed as Chairman. This Committee includes representatives of all timber interests in the Commonwealth and directs all activities on timber standards. A detailed programme of work was drawn up, priorities were allocated, and the work was channelled through six sectional committees including one each on Wood Technology, Wood Utilization—general, Wood Utilization—engineering, Plywood, Wooden Packages and Cases, and Timber Structures. The co-ordination of activities of these committees is the function of an executive of the Timber Industry Committee comprising the chairman, the chairmen of the two major sectional committees, a sawmillers' representative and a timber merchants' representative. Two members of the Utilization Section of the Division are technical liaison officers on all committees and the officer-in-charge is chairman of two sectional committees.

Revised standard grading rules for Western Australian timbers comprising in all 28 specifications were finalized and published. Other standards issued during the year included the revised standard schedule of Dimensions of Structural Timbers for use in domestic building construction and Australian Standard Grading Rules for sleepers for 24-in. gauge railway track (sugar-cane industry). In the interim housing series, specifications were published dealing with timber clothesline posts and bathroom cabinets. A number of other specifications in the interim housing series were considered but not finalized. The revision of the standard dealing with the nomenclature of Australian timbers was initiated. A panel of the sectional committee on timber structures commenced the preparation of a draft code of practice for timber construction in single-story buildings. Work continued on the preparation of a glossary of standard terms and definitions to be used in forest products research work throughout the British Commonwealth.

Field studies were carried out to provide basic data for the revision of standards dealing with milled products and with scantling timbers. Portable testing apparatus was constructed and operated in the field to determine the influence of defects limited by standard specifications on the strength and stiffness of timber used in house construction.

(*f*) *Other Investigations.*—Mill studies were carried out to determine the effects of salvage treatment on the utilization of fire-killed *Eucalyptus regnans.* The recovery of select, standard, and sub-standard grades from standing trees and from trees that had been salvage felled, dumped, and subjected to water sprays during the summer months was investigated.

Further information and advice on sub-floor heating as given, particularly in reference to the proposed nstallation at the new Australian National University t Canberra.

XIII. BUILDING.

1. General.

Australia is faced, as are other countries, with a emand for buildings, not only houses but also major works such as dams and power stations, which far xceeds the capacity of the building industry. It also as a difficult task in adapting traditional materials o new constructional techniques and in producing basic upplies from local raw materials.

The building research work of the Organization is undertaken mainly by its Building Research Section, which collaborates closely with the Commonwealth Experimental Building Station of the Department of Works. Work on timber is concentrated in the Division of Forest Products and is reported in Chapter XII. Work on house foundations is being undertaken by he Division of Soils (*see* Chapter II., Section 4 (*a*)) and work on cement and ceramics by the Division of Industrial Chemistry (*see* Chapter XVI., Section 3 (*a*) (*c*)).

Building Research Section.—The remainder of this Chapter outlines the work of the Building Research Section, which has its laboratories at Highett, Victoria.

The year under review was characterized by steady progress in investigations already begun, the only new project of importance being work on architectural acoustics.

The Section has given appreciable assistance to manufacturers in all parts of Australia interested in increasing the production and improving the quality of building materials. It has also taken an active part in the work of the various committees of the Standards Association of Australia engaged in the preparation of specifications and codes relating to building.

Grateful acknowledgment is made of the assistance afforded by the Victorian Housing Commission in making available, close to the Laboratory, a V.H.C.-type prefabricated concrete house for experimental purposes.

2. Physical and Mechanical Testing Laboratory.

With the installation of additional equipment the Physical and Mechanical Testing Laboratory is now in a position to fulfil its functions as a testing centre for other branches of the Section.

(*a*) *Weathering Studies.*—Considerable importance is attached to the development of short-term laboratory tests to determine the probable life of building materials under natural conditions of exposure in various parts of Australia, and an investigation on variations in the intensity of solar radiation has been commenced to obtain information from which more rational test methods could be evolved.

(*b*) *Concrete Roofing Tiles.*—Research on concrete roofing tiles continued on a small scale and resulted in the development of a spraying device for applying a mortar finish which is expected to improve the appearance and durability of the product.

(*c*) *Damp-proof Course Mortars.*—To provide the data required for the preparation of an Australian standard specification, the properties of damp-proof course mortars are being investigated. Attention has been concentrated on an examination of the strength, workability, and permeability of commercially available mortars. A permeability test, by which the rate of capillary movement of water through the mortar can be measured, was developed, and showed that mortars with waterproofing admixtures can be far less permeable than plain portland cement mortars. However, it was found that none of the factory-prepared damp-course mortars or mortars to which proprietary waterproofing admixtures were added was completely impermeable. No criterion for the degree of impermeability necessary for satisfactory performance of these mortars as damp-proof courses has yet been established. It is clear that this is closely related to the rate of evaporation and is therefore dependent on the conditions of usage. Further laboratory and field investigations will be required before any definite recommendations can be made.

(*d*) *Properties of Australian Building Sands.*—A start has been made on the systematic examination of Australian building sands. Such basic information is primarily required for the research programme of the Section, but it will also be of considerable value to the building industry generally.

(*e*) *Other Investigations.*—Measurements have been made of the shrinkage of the walls and floors of the experimental V.H.C. concrete house. During the eleven-month period since the erection of the house, shrinkages from 0.02 to 0.08 per cent. have been recorded.

(*f*) *Mechanical Testing Equipment.*—A 60,000-lb. universal testing machine has been installed and negotiations are in progress for the construction of a 250,000-lb. universal machine.

3. Concrete Investigations.

Experimental work has continued on two main projects: an investigation into the preparation, properties, and uses of foamed concrete, and a fundamental study of air-entrainment, in co-operation with the Division of Industrial Chemistry. The Division of Industrial Chemistry is also carrying out work on the expansive reaction between cement and aggregate. (*See* Chapter XVI., Section 3 (*a*).)

(*a*) *Foamed Concrete.*—Investigations into the factors involved in the preparation of foamed concrete have continued. The following observations were made:—

Of a large number of foam-forming agents tested, the following only were found suitable:—Resinate compounds, alkali derivatives of sulphated fatty alcohols, and certain sodium alkyl aryl sulphates, stabilized with sodium carboxymethyl cellulose and hydrolysed animal glue (with or without the addition of aluminium sulphate).

When foaming was produced by agitating all the constituents together, mixing times in excess of 30 minutes had an adverse effect on the properties of the final product.

When cement slurries were aerated with 0.5 per cent. of stabilized sodium resinate and aluminium powder up to 0.2 per cent. of the weight of the cement added, the approximate dry density in lb. per cubic foot of the products so obtained could be calculated from the formula 48.5 — 132a where " a " is the percentage of aluminium powder by weight of cement. For 1:3 cement/sand mortars using 1.5 per cent. of stabilized sodium resinate and aluminium up to 0.7 per cent. the corresponding formula was 91 — 40a.

Aluminium sulphate, calcium chloride, sodium carbonate, sodium silicate, and triethanolamine are all effective in increasing the rate of hardening.

(*b*) *Air-entrainment Studies.*—Considerable attention has been paid to the development of a standard laboratory method of mixing cement pastes with foaming agents to ensure that results can be reproduced readily and accurately and that the maximum quantity of air is entrained. With the technique finally adopted it is possible to reproduce results with a mean deviation of 2–3 per cent.

The effects of the following factors on the air content of a cement paste have been studied systematically:—Time of mixing, vigour of stirring, water/cement ratio, temperature, type of cement, alkali content and concentration of foaming agents used (a series of sodium alkyl sulphates).

A visual study has been made of the air bubbles entrained in hardened portland cement paste samples. It was found that an increase in the amount of a foaming agent in a cement paste not only increased the quantity of air entrained, but also resulted in smaller bubbles.

4. MASONRY INVESTIGATIONS.

There has been a general improvement in the facilities and equipment available. The installation of the pilot plant for clay investigations is now practically complete and full-scale technological examinations of Australian clays are possible. Part of the pilot plant equipment for work on lime is also available and preliminary investigations on the suitability of Australian limestones and allied materials for lime making will start shortly.

In December, 1948, the officer-in-charge of masonry investigations returned from a nine months' visit to the United Kingdom, Western Europe, and North America. Valuable contacts were made with research and industrial organizations concerned with many phases of the building industry.

Work on clays is being undertaken also in the Division of Industrial Chemistry as part of its programme of ceramics research (*see* Chapter XVI., Section 3 (c)).

(*a*) *Clays and Clay Products.*—(i) *Survey of the Clay Deposits and the Heavy Clay Industry in Australia.*—A survey of the clay deposits and of the brick, tile, and pipe plants throughout the Commonwealth was begun some two years ago to obtain a background to the heavy clay industry in Australia and thus to establish a basis for co-operation with and assistance to the industry.

In the past year the industry throughout Tasmania and southern Queensland has been covered and further works in Victoria and New South Wales have been visited.

It is apparent that within each State there are large resources of clays eminently suitable for the manufacture of all types of clay products. In Melbourne, Sydney, Adelaide, and Hobart, clays of the non-plastic shale type predominate as the raw materials for bricks, whereas in Perth, Brisbane, Launceston, and most country areas, plastic clays are more frequently used than shales.

It is apparent that only an extensive re-organization of many existing works and the erection of a number of new works operating on modern lines will overcome the present and future shortages of clay building units. A shortage of labour is probably the most serious factor in retarding output and this is likely to continue until the industry is modernized. Modern practices developed overseas give proof that with up-to-date methods of manufacture, particularly the installation of tunnel kilns for brick manufacture and general mechanization throughout the industry, the heavy clay industry can be made as efficient and as attractive to labour as any other heavy industry.

The Section has continued to give advice in connexion with the erection of the New South Wales State Tile Works. The clay deposits and proposed sites of prospective works in Victoria, Tasmania, and Queensland have been examined and preliminary advice given in each case on the most effective utilization of the clays, methods for clay winning, general equipment and plant, plant layout, and the installation of tunnel kilns. Assistance has also been given in the modernization of two old country brick and tile works in Victoria. The practical value of such advice is demonstrated by the immediate increases in production of 15,000 bricks per week in one works and 35,000 in another, with a simultaneous saving in fuel in the latter case, by the adoption of suggested improvements in the setting of bricks.

(ii) *Clay Technology.*—Clays from Bairnsdale, Colac, Echuca, Hamilton, Nyah, St. Arnaud and Warrnambool in Victoria; Blacktown, Bulli, Illawarra and Wollongong in New South Wales; Toowoomba in Queensland; and Hobart in Tasmania, have been examined during the year and recommendations made as to their handling and treatment under industrial conditions.

An investigation of clays from St. Arnaud, which show certain very unusual features, is being made. When moulded with water they assume a rubber-like consistency and when heated show a sudden breakdown at 1,150° C. with vitrification and a very marked concurrent shrinkage.

(iii) *Publications.*—To assist the heavy clay industry, a series of circulars is being prepared on pit operations, preparation and moulding of clays, drying and burning.

(iv) *Miscellaneous.*—At a meeting in London last year, a sub-committee of the Comité International pour l'Etude des Argiles was set up to investigate the possible standardization of the differential thermal method for clay analysis. Several laboratories throughout the world have agreed to co-operate and each will carry out, according to its own normal procedures, the differential thermal analysis of a set of standard clays or related hydrous minerals. The Section was asked to supply bauxite, one of the minerals to be examined. A high-grade bauxite, from Gippsland, Victoria, has now been beneficiated in the Section and prepared for distribution to the participating laboratories.

(*b*) *Lime and Lime Products.*—(i) *Survey of the Lime Resources and the Lime Industry in Australia.*—A survey of the lime resources and the lime industry in Australia along lines similar to those for the clay industry has been started. As with the survey of clay deposits, the various State Departments of Mines have been extremely helpful. They have supplied valuable data on the limestones, marbles and chalks of Australia and on the deposits being worked for building stone or lime.

Because of requests for advice from firms contemplating either improvements to established works or the setting up of new plants, visits have been made to the sites or proposed sites of the works concerned in Victoria, Queensland and Tasmania.

(ii) *Mortar Investigations.*—With the grave shortage of portland cement in several States and the recognition of certain troubles arising from the use of high cement mortars in masonry construction, interest in the revival of the use of lime mortars is growing. A comprehensive study has therefore been started into the properties of mortars. Mortars of composition varying from straight lime to straight portland cement types will be studied at regular intervals after preparation, over a period of a few weeks to several years.

(iii) *Efficacy of Carbide-waste Lime in Mortars.*—Carbide lime, which has been used for mortars in New South Wales, is claimed to be inferior to quicklime or hydrated lime. A preliminary study was undertaken to determine the reason for reported failures. Studies so far indicate that the strengths of the carbide lime mortars are lower than those of ordinary lime mortars. The differences in strength may be attributed either to the presence of sulphides in the carbide limes or the differences in the crystalline structure of the limes produced, on the one hand, from the interaction of calcium carbide and water and, on the other, by the calcination of calcium carbonate.

(*c*) *Sand-lime Bricks.*—Interest in the production of sand-lime bricks has been revived in Australia recently, and contact between the Section and firms contemplating the manufacture of sand-lime bricks in Tasmania, Victoria, New South Wales and Queensland has been made. Visits have been paid to the works already established and advice given on the raw materials and sand pit operations. The properties of the local bricks are being investigated.

(*d*) *Masonry.*—Studies were started on the causes and means of prevention of efflorescence and deterioration of brickwork and stone masonry. In preliminary surveys three types of efflorescence have been recognized. Firstly, "salt damp", which appears as a white efflorescence on bricks and is associated, in extreme cases, with a complete loss of strength of bricks or stone and frequently also with the simultaneous decomposition of the mortar. Secondly, white efflorescence, which appears on either bricks or mortar but seldom on both simultaneously; generally the effect on the mortar is slight whereas that on the brickwork is quite appreciable and intense spalling may be evident. Thirdly, a yellow or greenish staining, which appears on the bricks; although it is patchy and unsightly no apparent deterioration is associated with its presence.

Preliminary investigations in South Australia and New South Wales indicate that the "salt damp" encountered results either from the presence of soluble salts within the masonry structure itself or, more frequently, from the adsorption of salts from external agencies such as the soil or surrounding atmosphere. The effect can be particularly severe in the vicinity of the sea coast where spray with a relatively high content of salt may contaminate the atmosphere for some distance inland. The destructive action results from alternating wet and dry conditions giving rise to repeated solution and re-crystallization of salts within the brickwork, leading eventually to the gradual fretting away of the surface of the masonry.

Examination of samples of the white efflorescence common in Adelaide has shown that the main component is sodium sulphate with traces of calcium sulphate. From analyses of the water, sand, lime, cement and bricks used it would appear that the efflorescence has its origin in the cement used in the mortars. No case of efflorescence was found in masonry in which straight lime mortars were used.

The yellowish or greenish efflorescence appears to be associated with the use of coal measure fire clays in the manufacture of bricks. It is most pronounced in underburnt bricks, and is apparently due to the presence of vanadium salts in these clays.

5. SURFACING MATERIALS.

(*a*) *Floor Surfaces.*—Although concrete floors for dwellings have certain advantages, there is considerable objection to their use on the score that they are uncomfortable because of their hardness or coldness or both. A study of the physiological basis of these objections and ways of overcoming them has been continued.

(i) *Indentation Tests.*—To examine the possibility of a correlation between indentation characteristics (including rate of recovery when the load is removed) and foot comfort, an indentation tester based on that described in Report B.M.S. 14 of the United States National Bureau of Standards has been constructed and used to study the behaviour under load of commercial floor surfacing materials. These experiments have shown that to avoid "punching" effects, a spherically-ended indenting tool is desirable, and that it is not practicable to test all such materials under the same conditions of load, size of tool, &c. This has necessitated a study of the separate effects of time, load, size of indenting sphere, and thickness of specimen on the indenting constants at constant temperature. This study has been handicapped by the almost uncontrollable variables introduced by the heterogeneous nature of many of the common floor surfacing mixes and, in consequence, a search has been commenced for a homogeneous material of suitable flow characteristics which can be used for such calibration tests.

(ii) *Abrasion Tests.*—The Taber Abraser (which is becoming accepted as a semi-standard in the United States of America) has been used to accumulate experimental data on the abrasion resistance of flooring materials. These will be used for comparison with overseas data on new flooring materials. This instrument suffers from the very common defect of abrasion testers, that the rate of abrasion changes as the test proceeds. To overcome this, a machine with constantly renewed abrasive has been designed.

(iii) *Experimental Floors.*—A variety of experimental floors has been laid in laboratories, workshops, lecture room and the experimental Victorian Housing Commission house. These floors have been kept under observation throughout the year for their behaviour under traffic. One particular set of nine strips of different types of floor surfacing has been laid on a concrete slab sub-floor placed directly on the ground without any moisture-resistant course or membrane. As the site is badly drained this experiment should prove a severe test of the ability of these materials to perform satisfactorily without a damp-proof membrane.

(*b*) *Bathroom and Kitchen Wall Surfaces.*—Laboratory work has been concentrated on routine testing of commercial wall surfacing materials for resistance to soap and other household hazards and an examination of the properties of soap solutions.

Field trials of commercial lacquered hardboard and polystyrene tiles have been commenced. Where polystyrene tiles have been installed over plywood and insulating board, shrinkage cracks are apparent in the mastic at the joints, but this defect has not appeared when a concrete backing is used. In one case where it was possible for water to reach the mastic (white lead putty type) behind the tiles, complete bond failure occurred in ten months. The tiles themselves have behaved well in service, except where exposed to heat.

(*c*) *Gypsum Plaster.*—There is still much doubt and confusion concerning exactly what takes place in the process of manufacture and in the setting which occurs when plaster is mixed with water; its manufacture and use are almost entirely by rule of thumb. A comprehensive study of the material is being made in the hope that with a better understanding of what takes place a rational approach may eventually be made to the twin problems of improving methods of manufacture and of use.

Considerable attention has been directed to testing methods, and experimental work carried out for the Standards Association of Australia has assisted in the preparation of a new standard specification for gypsum plaster for use in the manufacture of fibrous plaster sheet.

Samples of all Australian commercial plasters have been obtained and are being analysed. Results show a wide range of purity, some of the worst plasters containing less than 80 per cent. of calcium sulphate.

Work has continued on the development of apparatus for determining particle size distribution of plasters by air elutriation. Most of the obvious sources of error in the original apparatus now appear to have been eliminated.

Measurements of specific surface by air permeability have been made on 30 commercial plasters. The results show a wide variation between plasters, the highest figure being approximately twice the lowest; the coarsest shows about twice the surface area of local portland cement.

As a result of the erection of houses constructed of prefabricated load-bearing gypsum slab walls in some of the drier parts of Victoria and South Australia and the desire of the manufacturers to extend their operations into the areas of higher rainfall, attention has been given to the weather-proofing of plaster. A number of treatments has been tried in an Atlas Weatherometer and the more promising are now being more extensively examined by outdoor exposure at Highett.

(*d*) *Rendering.*—Routine tests have been made on a large number of rendering mixes in connexion with the work on the rendering boards.

A systematic survey is being made of the effect of the size of flow tables on the results obtained in the flow testing of mortars.

6. BUILDING BOARDS, INSULATING MATERIALS, AND ACOUSTICS.

(*a*) *Building Boards.*—Some extension has been possible of the investigations into the relation between the properties of boards used as bases for external rendered finishes and the behaviour of the rendered walls when exposed to the weather.

Fifteen panels have been mounted on the northern walls of experimental huts. It was found that cracking is much less prevalent in those panels in which a period of approximately three weeks was allowed between the coats of rendering than in those to which the three coats were applied within ten days. The need for joint treatment with wood-wool slabs has also been confirmed.

A sample of fibre extracted from the Pandanus palm was received from New Guinea and tested to determine its suitability for use as reinforcement for fibrous plaster. It proved quite satisfactory for the purpose.

Work on building boards is also being undertaken within the Division of Forest Products (*see* Chapter XII., Section 6 (*f*)).

(*b*) *Thermal Investigations.*—Because of lack of space the 12 inches by 12 inches and the 48 inches by 48 inches thermal conductivity apparatus has not yet been installed. However, accommodation will be available soon and it will then be possible to begin work upon the measurement of the thermal conductivity of Australian insulating materials. A knowledge of this property will satisfy a long-felt need of designers for accurate information upon which to base calculations.

It is a relatively simple matter to calculate the heat flow into or out of an enclosed space when the internal and external conditions remain constant. To perform the same calculation under varying conditions is a prohibitively difficult task which becomes impossible if the conditions of heat transfer vary with time or temperature. The heat flow can, however, be determined by the use of an electrical "analogue". By feeding appropriate signals into the electrical circuit, it is possible to measure the electrical response at any given point on the circuit and to transfer the result into terms of the thermal case. It is proposed to construct such an analogue and investigations have been made to determine the minimum number of capacity "lumpings" tolerable and the electrical circuit for the case of a dwelling.

(*c*) *Architectural Acoustics.*—The first problem being studied is the acoustic behaviour of rooms, halls, &c. A theoretical investigation has shown that in a scale model of a space at a correspondingly changed frequency, the wave pattern will be the same. This will now be checked experimentally and, if the theory is confirmed, it will then be possible, by the use of models, to study in the laboratory the properties of halls, &c., and to assess the likely acoustic behaviour of any proposed buildings. The literature has been reviewed to ascertain the best methods for measuring certain of the properties which need to be known before the main work may proceed.

7. ORGANIC MATERIALS INVESTIGATIONS.

(*a*) *Caulking Compounds.*—Laboratory investigations have been confined to the continuation of routine testing of mastics in an "expanding joint" device and to analyses of the materials used in installation tests, in an effort to correlate observed performance in these tests with composition.

Observations have been made at regular intervals of the condition of mastic samples exposed to the weather in grooved blocks since 1947. No striking change has occurred in these specimens in the past twelve months and it is tentatively concluded that materials showing satisfactory condition after the first few months of exposure may be expected to deteriorate but slowly thereafter.

Wall joints in the experimental Victorian Housing Commission concrete house and the joints between adjacent rendered panels on the walls of experimental huts at the Laboratory were filled with several caulking materials selected as a result of the foregoing tests. Performances in these situations are being recorded as part of the study of the behaviour of mastics under practical conditions. The preparation of an experimental roof section simulating the paved construction of a traffic-bearing bituminous-membrane flat roof was completed and the spaces between the 2-ft. square concrete paving slabs were caulked with 24 different joint sealing compositions. These materials were principally of the bituminous and bitumen-rubber based variety. In an attempt to render evaluation quantitative, electrodes were incorporated during construction beneath each joint. By flooding the surface with water and placing a wandering electrode on the upper surface of the joint under test it is thus possible (by measuring the electrical resistance between the electrodes) to gauge the efficiency of the seal in question.

At the request of the Victorian State Rivers and Water Supply Commission, and on the basis of preliminary results, a selection was made of six of the more promising materials for joint sealing trials in a concrete irrigation flume at Robinvale, in the Victorian Mallee district. The sealing of the butt joints between the 40-ft. sections of this flume was considered a difficult and pressing problem and an excellent opportunity for the study of selected sealing compositions under rigorous practical conditions. Accordingly, test joint fillings were applied over a 200-yard section of the flume. Subsequent inspections of this experiment have indicated promising results with at least two of the treatments applied and these two compositions are to be tested further by application to the remaining flume joints. A.B.R.L. pneumatic caulking gun of modified design has been constructed to facilitate the projected larger scale operations.

(*b*) *Bituminous Roofing Materials.*—Systematic examination of the proximate composition and of the quality of the ingredients in Australian bituminous roll roofing materials has been continued concurrently with exposure studies, both of small rectangles of each material and of full-scale roofing membranes. Two urther flat roof membranes comprising a total of ,600 square feet were laid and incorporate variations in type of roofing felt and of bonding or laminating bitumen. The former variation is in continuation of he study of the correlation between felt quality and membrane performance. The latter variation was ncorporated to obtain information on the effects on performance of various roof construction techniques.

Different protective surfacing treatments have been applied as part of a programme to determine the bearing of this factor on membrane durability. Confirmation is already available from this work of the fact that only coatings without film-forming properties are suitable. In this category good results have been obtained to date with bituminous "cut back" paint pigmented with leafing aluminium particles.

Some small blisters have now appeared on these test membranes, but laboratory tests have provided evidence to suggest that blistering or delamination may be associated with some permeability of the membrane to moisture and the deposition of moisture between ayers when the membrane is alternatively heated and cooled in contact therewith.

At the request of the Victorian Housing Commission, tests were made to determine whether asbestos cement sheet could be rendered suitable for use as a protective sheath over bituminous membrane roofs, as under ordinary conditions the asbestos cement buckled and ceased to function efficiently. As the result of experimental work it was found possible to correct this trouble by painting the sheets with bitumen-based aluminium pigmented paint.

At the request of the Department of Works and Housing, samples of Swedish roofing felts available for import into this country were examined in the Laboratory and compared with typical Australian materials.

Assistance has been afforded to the Standards Association of Australia in carrying out laboratory work on and in preparing draft specifications for bitumen-coated damp-proof courses with fibre-felt bases and lead centres.

8. DECORATION OF FIBROUS PLASTER.

Investigations on this project have been continued. Progress was reviewed by the Co-operative Project Committee, and recommendations regarding future investigations were made to the Building Research Section's research team.

As a result of further field studies, and on the basis of experimental work in the laboratory, the problems associated with this project have now been defined as: (1) the growth of mould on bare and decorated fibrous plaster; (2) surface stains attributable to the undecorated fibrous plaster surface; (3) stains associated with the decorated fibrous plaster surface; (4) adhesion failures in fibrous plaster decorative treatments; and (5) moisture changes and the porosity of plaster in relation to surface staining and adhesion failure.

As no great reliance can be placed on information gleaned from field surveys on the history of any particular defect of interest, it was considered necessary to study experimentally erected fibrous plaster surfaces for which accurate records of treatment would be available. The fixing and decoration of linings in experimental huts Nos. 1 and 2 in the grounds of the Laboratory were completed and the lining of experimental hut No. 3 was undertaken. The installation and decoration of fibrous plaster ceilings in the experimental Victorian Housing Commission concrete house was completed and an experimental re-decoration of two ceilings in a private home in North Balwyn, in which severe adhesion failure had occurred, was undertaken. These units, together with a private home in Box Hill, have been kept under observation. Adhesion failures were observed after a short period of time in certain flush joint areas in the Victorian Housing Commission house and "sulphide" staining defects were noted on the kitchen ceiling of the Box Hill unit following a spell of damp weather in June, 1949. To date no trouble has developed in the dwelling at North Balwyn.

The plastering and painting treatments in the first two dwelling houses referred to and in experimental hut No. 1 were more or less normal, but in applying linings to experimental huts Nos. 2 and 3, the number of flush joints incorporated on walls as well as ceilings was greatly increased by cutting the sheets into 18-in. wide strips. In this way the number of focal areas for trouble (viz. flush joints) was greatly increased, permitting the performance of "drag-net" experiments in which a range of all the variables considered to be possibly associated with the common surface defects was repetitively introduced. Unfortunately, none of the defects sought has as yet occurred in hut No. 2; it is now believed that atmospheric conditions may have a considerable bearing on the development of defects and that the time of the year during which this hut was decorated (spring and early summer, 1949) was badly chosen. The experiment in hut No. 3, on the other hand, was commenced during May, 1949, and conditions in this hut already appear to be more promising.

Progress was made in the study of the several problems defined above as follows:—

(i) *Mould Growth*.—The conclusion reported previously that mould growth is not a widespread cause of disfigurement of fibrous plaster surfaces in Australia has not been varied as a result of subsequent investigations. It is suggested that the mandatory provision of ventilators in habitable rooms in most Australian houses has a bearing on the low incidence of mould growth in this country.

(ii) *Surface Stains Attributable to the Undecorated Plaster Sheet*.—"Fibre" stains, which were the result of use of inferior grades of sisal or of teased rope, have become a problem of small significance following improvements in supplies of satisfactory sisal fibre.

(iii) *Stains Associated with the Decorated Plaster Sheet ("Sulphide" Stains)*.—The mechanism associated with this particular trouble still remains unsolved. It has been ascertained that sufficient iron is usually present in water-soluble form in most plasters and in most water-paint mixtures to give rise to this stain, and samples of both these materials have been shown to stain when treated in the laboratory with sulphide solutions. A survey has been commenced of the soluble iron contents of a range of plasters and of different shades of various types of water paints with the aim of eventually relating the staining intensity to the iron content of the system.

Considerable evidence has now been accumulated to suggest that stain development is related to surface moisture content, but quantitative proof of this is not yet available. One theory is that sulphide staining is the result of surface bacterial activity during periods of high surface moisture content, resulting in the metabolic evolution of hydrogen sulphide. There are two possible sources of sulphur in the system under consideration, the wall material itself—calcium sulphate—and organic sulphur in the protein binder of the water paint. Of these, bacterial reduction of the organic sulphur appears more likely, and although initial attempts to isolate such organisms were not successful this line of attack is being pursued in collaboration with the Bacteriology Department, University of Melbourne.

(iv) *The Mechanism of Adhesion Failure: Porosity Studies.*—In the course of investigations on the resin impregnation of plaster, some results have been obtained which suggest that in certain cases defective adhesion may be associated with inability of the molecules of the paint binder to penetrate or "key" into the plaster surface. On this thesis a working plan to study paint binder penetration and resultant adhesion has been prepared.

XIV. WOOL TEXTILES.

1. General.

In Chapter VII., reference was made to the responsibilities of the Organization for research on wool production and wool textiles. As mentioned in earlier reports, difficulties have been experienced in obtaining the services of a senior scientist suitably qualified to act as Chief of a Division of Wool Textile Research. Nevertheless, a considerable programme of research is in hand embracing many problems associated with wool in the textile field.

Some of this work has been in progress for several years and important results have been obtained, especially in the investigations which the Organization's Division of Industrial Chemistry has been making to assist the fellmongering industry.

The Organization is building up special facilities for wool textile research at Geelong. Staff and equipment for the study of the various stages of the intricate processes whereby raw wool is converted into finished fabrics are being built up. Until buildings become available the Gordon Institute of Technology at Geelong has generously provided laboratory space to permit a start to be made on some aspects of the work.

At present three laboratories are grouped under the Wool Textile Research Section and generally co-ordinated from Geelong, namely—

(i) The chemical and physical investigations, at present housed in laboratory space made available by the Textile College of the Gordon Institute of Technology in Geelong.

(ii) Wool processing investigations being commenced in a temporary laboratory housed with the Fleece Biology Section of the Division of Animal Health and Production at Randle-street, Sydney.

(iii) Solvent scouring investigations being conducted in a temporary pilot plant and laboratories at the Explosives Factory, Maribyrnong, Victoria.

Acknowledgment is made of co-operation afforded by the Gordon Institute of Technology, Geelong, both in the provision of research facilities and accommodation, and in the interest taken in the development of the Organization's work in Geelong.

The activities of this Wool Textile Research Section are described in Sections 2-4 below.

Work on the wool fibre, wool protein chemistry, wool scouring, and wool biochemistry is being undertaken within the Division of Industrial Chemistry and is described in Sections 5-8 below.

Work on the wool fibre being undertaken within the Division of Physics is described in Section 9 below.

The Division of Entomology is studying the digestive processes of wool-eating insects as part of a fundamental investigation of the problem of protecting wool from insect attack (*see* Chapter IX., Section 5 (*a*)).

2. Wool Chemistry.

Methods of forming vinyl polymers in wool are being investigated and studies are being made of the properties of the fibres after treatment. The research is first of all concerned with the synthesis of the resin within the fibre using suitable catalysts and the first task has been to find a catalytic system which could be conveniently applied in industry. Ammonium persulphate is being examined as a possible reagent for this purpose and it has been found that substantial amounts of methacrylic acid can be polymerized in wool when applied from a hot bath containing a small amount of this compound. The investigations are now concerned with finding the optimum conditions for carrying out the reaction. It is proposed to treat wool samples so as to obtain products with varying amounts of resin and then observe physical properties of such materials with particular reference to their wear resistance. Studies are being undertaken to develop a satisfactory method of ascertaining wear resistance and experiments are in progress using the Martindale abrasion testing machine which was developed by the Wool Industries Research Association.

In addition to wear resistance, other properties of the treated materials are being studied, such as shrinkage on washing, and the effect of internal and surface deposits of a series of resins on the shrinkage properties of wool is being examined.

It has been found that if the cystine in wool is reduced by means of sodium bisulphite or thiolacetic acid, polymers can be formed in the treated fibres simply by immersing them in a bath of the monomer. In other words, the wool has produced its own catalyst in the form of reduced cystine. This reaction is being investigated in greater detail as it is of fundamental interest in connexion with the occurrence of cystine in wool.

Another branch of research is concerned with forming polymers within the wool and then linking them chemically to the wool itself with the view of producing a fibre of greatly enhanced strength.

3. Carbonizing.

The laboratory for carbonizing investigations in Sydney has only just been completed and, as a result, no research activities can be reported for the current year. The officer who is to supervise these investigations has been assisting the industry by a study of a number of problems referred to him.

4. Solvent Degreasing.

At the end of 1948 the office and laboratory of this investigation were moved from temporary premises in Melbourne to a group of buildings which have been made available by the Department of Supply and Development at Maribyrnong. The remaining period of the year was spent in establishing and equipping the laboratory and in installing the pilot plant equipment for investigations of the solvent degreasing of wool. The electrical installations and the outfitting of the laboratory at Maribyrnong are now well advanced and should be completed shortly. Major units required for the erection of the solvent degreasing pilot plant have now been delivered and it is hoped to have it in operation soon.

5. Scouring.

The mechanism of scouring wool with a soap-soda solution containing an emulsified solvent has been further studied. A mathematical analysis of experimental results has led to a more exact understanding of the process and should assist materially the scaling up to pilot plant equipment. The next stage is to test the process on a pilot plant. In the process of this work a rapid method for the estimation of soap in scour iquors has been developed. This method could facilitate adequate control of commercial scouring processes.

Work has commenced on two other problems of wool scouring. In using non-ionic detergents it has been considered necessary to work at elevated temperatures. Using a commercial detergent of this class the temperature dependence of scouring is being correlated with the physical properties of the detergent in an endeavour to understand its action and, if possible, to develop conditions under which lower temperatures may be used. Another feature of non-ionic detergents is that though they may be effective in removing grease, sometimes cleaned dirt particles re-deposit on the scoured wool. This problem is being attacked by a method analogous to chromatographic adsorption in a column of wool.

6. PROTEIN STRUCTURE.

The programme of work on the structure of the wool protein, keratin, and other related fibrous protein systems has proceeded along three main lines during the past year. A senior protein physicist has been appointed to co-ordinate the investigations of the three groups involved.

(*a*) *Electron Microscopy.*—Studies on muscle and tendon, using the electron microscope, have provided new data on cellular organization and on the distribution of inorganic constituents along these protein fibres. The protofibrils of muscle show the same macromolecular structure described previously for those of keratin, an observation which lends support to the linear-aggregate model of fibrous proteins. A theory of the genesis of these linear aggregates, as a result of electrokinetic interactions, is supported by a number of experimental observations.

(*b*) *X-ray Crystallography.* — Accurate structural analyses of certain amino acids and peptides are being pursued in an attempt to evaluate their influence on protein molecular configurations. Important and unsuspected structural features have been discovered in the initial work on certain amino acids.

(*c*) *Infra-red Spectroscopy.*—Information on the nature and orientation of various molecular groups in amino acids, synthetic peptides, and natural proteins is important for X-ray structural analysis; to obtain these data equipment using polarized radiation for near infra-red absorption spectroscopy has been developed and has been used with success. A novel spectrometer for the far infra-red region, using echelette zone plates, has also been designed for investigations of the skeletal frequencies, characteristic of the whole protein molecule.

7. PROTEIN CHEMISTRY.

Work in this field has developed along two main lines, first, the mode of formation of keratin and other constituents of the wool root, and second, the fractionation and characterization of certain extra-cellular mould enzymes.

(*a*) *Biochemical Studies on Wool Roots.*—The study of the wool root should lead to improved knowledge of the composition of the wool fibre and thus a more effective use of physical and chemical treatments in the processing of wool, and also to a better appreciation of the function of nutrients required by sheep for the production of wool of satisfactory quality.

Using the method of paper chromatography, twelve amino acids have been detected in aqueous wool root extracts; of these glutamic acid, alanine, and glycine were invariably present. Peptides have also been detected and separated from the extracts by passing them through columns of starch and ion exchange resins, and preparations are being made for their further purification in an improved design of ionophoresis apparatus.

A system known as the tricarboxylic cycle, which other workers have shown to fulfil an important role in the synthesis of biochemical compounds in some animal tissues, apparently functions also in wool roots since most of the acids have been detected in ethanol-water extracts of wool roots. Several of the enzymes concerned in intermediary metabolism of the roots have been detected after release from the cells by grinding or by exposure to ultrasonic vibration.

(*b*) *Enzyme Investigations.*—Experience gained in the separation of enzyme proteins, which is less difficult than the separation of non-enzymic proteins owing to the specific catalytic properties of the former, should be applicable to the separation of the protein constituents of the wool fibres or wool roots. Moreover, when the proteolytic enzymes in a mixture, such as those produced by a strain of *Aspergillus oryzae* now under investigation, are separated and their specificities are established, it will be possible to use them to hydrolyse compounds extracted from the wool roots and fibres, as an aid to determining the structure of these compounds.

During the past year improved strains of *Aspergillus oryzae* have been selected and cultivated and as a result the yield of the proteolytic enzymes secreted into the liquid medium by the mould has been more than doubled. Mutants of the most active strain have been produced by irradiation of spores with ultra-violet light of known wave-lengths and the relative yields of the various enzymes produced by the artificially induced mutants are being determined. Their application is discussed below.

In the course of investigations on the concentration and purification of mould enzymes a method has been developed for the separation of the enzymes responsible for the hydrolysis of protein and carbohydrate respectively and also for the oxidation of certain compounds. A further stage in the purification of the first of these, namely, the protease fraction, has now been carried to such a stage that crystals containing at least two proteolytic components have been obtained from mould culture filtrates. This demonstration of the presence of more than one enzyme in the crystals emphasizes the danger of accepting crystallization as a criterion of purity in protein research.

In addition to their application to the determination of the ultimate composition of wool, the mould enzymes have possible uses in the fellmongering industry for loosening wool on skins, and large-scale trials to assess their use in the recovery of wool from sheepskin pieces have been initiated in several Australian fellmongeries. The study of the wool root should also assist in the development of improved methods of fellmongering by revealing the chemical nature of the constituents of the root; this should indicate the types of agent most likely to soften them and thereby release the fibres.

8. WOOL WAX.

One bale of Merino wool has been solvent extracted to obtain wool grease for research purposes. The industrial scale saponification of wool grease has proved difficult in Australia and a test of a German method has been made on a 40-lb. scale with some modifications. The process was successful and the fatty acids and alcohols were separated and obtained in good yield. Work is progressing on the separation and structure of the aliphatic and polycyclic alcohols. Lanosterol and related triterpene alcohols have been isolated in sufficient quantities to carry on structural investigations with this group of compounds. For this purpose many derivatives of these polycyclic triterpene alcohols have been prepared.

For the preparation of the aliphatic alcohols distillation methods have been devised. These involve distillation at very low pressures in the recently described spinning band and Bowman columns. The latter has been purchased, the former has been built and tested out here.

9. WOOL FIBRE.

(*a*) *Surface Structure.*—By arrangement with the New South Wales Department of Technical Education a console model electron microscope has been used for the study of the surface structure of wool fibres by the two-stage replica techniques outlined in the last report. Normal fibres and fibres subjected to various commercial finishing treatments have been studied, these treatments being chosen because of their practical interest and because they significantly change some surface properties of the fibres without producing any marked change in their structure as seen in the optical microscope. The results obtained support earlier conclusions that the wool scale consists of an underlying, resistant, longitudinal structure covered by a smooth and rather featureless layer which is mechanically and chemically less resistant. The commercial finishing treatments referred to appear to "etch" the surface by attacking this smooth layer, without destroying the scale structure. Their effectiveness in preventing felting is due to the fact that by this attack they weaken the edges of the scales, so that the difference in friction of the fibre rubbed towards the root or towards the tip is reduced.

Many scales show an interesting "fringed" edge, whose relation to the remainder of the scale structure is not clear.

(*b*) *Frictional Properties.*—The theoretical basis of Speakman's lepidometer, which measures the "creeping power" of a wool fibre under a rubbing action, has been investigated. It has been shown that the instrument measures a quantity which lies between the difference between the coefficients of static friction against and with the scales and the difference between the coefficient of static friction against the scales and of kinetic friction with the scales. From this it follows that the instrument in general exaggerates small frictional differences.

A new apparatus has been built in which the frictional properties of wool fibres are being studied at various humidities.

(*c*) *Fibre-length Meter.*—Preliminary experiments have shown that a strong electrostatic field will stretch wool fibres sufficiently to remove crimp; this stretching is, of course, reversible. It may be possible to use this as the basis of a fibre-length meter, in which the distribution of lengths of crimped and uncrimped fibres could be studied.

XV. FLAX.

1. GENERAL.

Control of the flax industry by the Commonwealth Government during the war has resulted in the building up of a modern and profitable industry. To meet problems peculiar to the industry in Australia, flax investigations commenced during 1937 were expanded at the request of the Flax Production Committee.

It is not expected that the recent decision of the Government to relinquish control of the industry will affect seriously the Organization's flax research programme, which is being carried out by its Flax Research Section with laboratories at Highett, Victoria. With a temporarily reduced flax industry the need for research to improve efficiency will increase in importance.

Flax Research Section.—In addition to its research on flax processing, the laboratory is engaged on investigations concerned with the spinning, bleaching, and weaving of flax yarns. The outcome of work on the bacteria responsible for water retting gives considerable promise of substantial improvements in water retting in Australia.

The Section has continued to receive close co-operation from the Flax Production Committee, whose assistance is gratefully acknowledged, and local spinning and weaving organizations have continued to provide assistance whenever called on. Close liaison has been maintained as in the past with the Waite Agricultural Research Institute and with the Departments of Agriculture in Victoria, South Australia, and Western Australia regarding agricultural work on field trials.

2. AGRICULTURAL PRACTICE AND FLAX QUALITY.

(*a*) *Survey of Factors Influencing Fibre Quality.*—During 1946 and 1947 details were collected regarding a large number of flax crops throughout Victoria. The details included the history of each field, its preparation, and information concerning the growing and harvesting of the crop. More recently, details of the mill processing of these crops have become available and an analysis of the results promises to give useful indications as to the best methods of producing high-quality flax.

(*b*) *Evaluation of Straw from Field Trials.*—As flax is cultivated primarily for its fibre, a very important part of field trials is to determine the quantity and quality of fibre in the straw as well as the weight of straw per acre. Tests have been made for those agricultural organizations in Australia which include flax field trials in their research programmes and on flax samples forwarded from New Guinea. The more important of these trials have been concerned with flax varieties, particularly rust-resistant strains, some of which have been produced in this country. Other trials have investigated the effect of rate and method of seeding, the time of harvesting, and the use of various fertilizers.

3. PROCESSING.

(*a*) *Deseeding.*—Modifications have been made to the standard type of deseeding machine to increase its efficiency. The usual reciprocating comb for removing the seed bolls has been replaced by a set of four rotary combs. The effect is to give four combing actions in the time previously taken by one, and also to reduce the noise and vibration set up by the machine.

(*b*) *Water Retting.*—Considerable effort has been devoted to working out details of the aerated ret, which is carried out in tanks in the normal way except that air is bubbled through the liquor during the process. This aeration permits the acidity of the liquor to be controlled so that the same liquor can be used repeatedly for up to 50 rets, which simplifies the effluent disposal problem and conserves water. Present indications are that aerated retting reduces retting time and does not impair the quality of the fibre.

Other retting investigations have included a mill scale comparison of a retting schedule developed at the Colac flax mill with the standard schedule, a comparison of the retting of cut and pulled flax, and the effect on retting of the presence of metallic copper and brass.

The study being made of retting bacteria has included a survey of the flora present on straw from various districts in Australia as well as from a number of overseas countries. The different bacteria have been isolated, identified, and their retting ability determined. It has been found that on straw from Belgium, the accredited home of high-quality flax, there are certain types of bacteria almost absent in Australia which are very effective retting agents. These facts suggested the noculation of Australian rets with the active bacteria. The results on a laboratory scale have been spectacular n that retting times have been greatly reduced and ibre grades raised appreciably. Ways and means of applying the idea on a commercial scale are being nvestigated. A combination of the inoculated with the aerated ret, whereby the bacteria are carried on in the liquor from ret to ret, may be a happy solution to the problem.

This work on retting bacteria has been substantiated by the fact that the Flax Production Committee recently received samples of fibre from Australian straw retted in Belgium, presumably in tanks with Belgian straw containing the active retting bacteria, and that the quality of this fibre was several grades higher than that obtained from the same straw retted locally.

(*c*) *Scutching.*—It has been realized for a long time that scutching, or the mechanical removal of the fibre from the flax straw, is perhaps the least efficient of all mill operations in that only about half the fibre is obtained in the form of line, the remainder being reduced to tow. A detailed comparison is being made of the performance of the scutching machines and their operation at the various flax mills in Victoria.

(*d*) *Preparing and Spinning.*—Full use is being made of the experimental preparing and spinning plant recently installed at the laboratory. Standard procedures have been established for comparing fibre samples and expressing spinning performance numerically. This includes the mechanical testing of the spun yarn.

4. Chemical Properties of Flax.

(*a*) *Fibre Analyses.*—The quality of flax fibre appears to be associated with its chemical composition. Analyses have shown, for instance, that the high-grade fibre from straw retted with an inoculation of the special bacteria mentioned above is significantly lower in wax and caustic soda solubles than the lower-grade fibre from the same straw retted normally. Such results are being studied as a possible means of throwing further light on the specific requirements of different retting bacteria.

(*b*) *Plant Analyses.*—Chemical analyses are being made of green leaf samples from a large number of flax crops to determine the levels of major and minor nutrient elements necessary for the growth of high-quality flax.

5. Physical Properties of Flax.

(*a*) *Flax Anatomy.*—The microscopical examination of Australian and overseas straw with special attention to fibre characteristics is proceeding. An extension of this work has been to study the development of the fibre in the growing plant. The effect of hail during the growing of flax has also been investigated.

(*b*) *Fibre Properties.*—Consideration is being given to the possibility of enumerating the quality of fibre by means of tensile strength and fineness measurements and so eliminating the personal factor now present in fibre grading. The main problem is to find the staff necessary to carry out such measurements on all the samples to be graded.

6. Other Vegetable Fibres.

(*a*) *Ramie.*—At the request of the Department of Commerce and Agriculture, investigations have been carried out to determine a method of cleaning ramie fibre produced by the process developed by Mr. M. M. Wise of Sydney and also to determine the spinning properties of the fibre so produced. The results have been communicated to those interested.

(*b*) *Other Fibres.*—During the year samples of fibre have been examined and reported on from sunflower plant, canna, kunai grass, pandanus palm, date palm, and stringy-bark.

XVI. INDUSTRIAL CHEMISTRY.

1. General.

Chemical processes are of major importance in many branches of secondary industry. In consequence, when the activities of the Organization were extended into the field of research for secondary industry, a Division of Industrial Chemistry was formed (*a*) to promote greater technical efficiency in established industries, (*b*) to stimulate the establishment of new industries, (*c*) to encourage the use of raw materials of Australian origin, (*d*) to seek substitutes for imported materials, and (*e*) to find uses for by-products not utilized.

The Division represents the major concentration of chemical research within the Organization, although much chemical work is undertaken within other Divisions. In addition to its basic chemical work of interest to many industries, the main lines of activity within the Division of Industrial Chemistry are on mineral utilization, cement, ceramics and refractories, organic chemicals and wool. Chemical work on building materials is carried out within the Building Research Section, on timber products within the Division of Forest Products, on wool within the Wool Research Section, on food processing within the Division of Food Preservation and Transport, and on minerals and metals within the Physical Metallurgy Section, the Ore Dressing Laboratories, and the Division of Tribophysics. The present chapter is concerned with the work of the Division of Industrial Chemistry.

Division of Industrial Chemistry.—From the time of its formation the Division has shared a site with the Division of Aeronautics, and many of the services have been set up to meet the needs of both Divisions. During the year under review the Division of Aeronautics was transferred to the Department of Supply and Development. It has been found possible to continue to operate many services on a common basis, including the library, the canteen, the main workshops and certain minor services. Moreover, it seems that the effective liaison between the scientific officers of the two Divisions, which has developed spontaneously over many years, will continue unimpaired.

Liaison with other Divisions has been strengthened by the secondment of additional officers to other parts of the Organization and by the Division's having had officers of three other Divisions as guest workers for periods of up to twelve months.

Close contact has been maintained with the universities and with industry. The specialized equipment of the Division is being used to assist in numerous research projects of the universities; guest workers are working conjointly with Divisional officers on a variety of problems; and several of the Division's officers are enjoying the hospitality of the scientific departments of universities and technical colleges. Indeed, a considerable proportion of the Division's work is done in close association with or in actual collaboration with the staffs of educational institutions. The general nature of the Division's relations with industry has been discussed in earlier reports.

In recent years it has been difficult to find suitable applicants for advertised positions, and some have usually remained unfilled. It is a pleasure to record, however, that as the Division is becoming better known, applications are being obtained in increasing numbers from overseas, and more than half the recent appointees to the research staff have come from Great Britain. Other appointments are being filled by senior students who, on completion of their period of study overseas, will join the Division.

Some progress has been made in the matter of obtaining additional working space. The Chemical Engineering Section will shortly occupy an additional unit of its factory type building, and the fitting up of two additional army huts for the Chemical Physics Section is well advanced. On the other hand, progress on the second main laboratory block is very slow.

Several aspects of the wool research programme of the Organization have been assigned to the Division. The Organic Chemistry Section is responsible for research on wool wax, and a comprehensive programme was drawn up early in 1948. Because of shortage of accommodation, progress has been slower than was hoped, but this work is well under way. The work on the principles of detergency, as applied to wool scouring, has been continued in the Physical Chemistry Section. The staffs of the Biochemistry and Chemical Physics Sections have been augmented in order to accelerate the research on proteins and enzymes which is essential for a better understanding of the ultimate constitution of wool and of its method of synthesis by the sheep. The Division possesses most of the extensive facilities needed for work of this type, and considerable progress has been made.

Chemical engineering plays a predominant part in the production of chemical and liquid and gaseous fuels from coal, and accordingly a start has been made on fuel utilization research in the Chemical Engineering Section. One of the Section's officers spent the greater part of the year under review in North America and Great Britain, becoming familiar with the research work in progress in this field.

The following description of the activities of the various Sections focuses attention on the work of the scientific and technical officers. The essential part played by the clerical and stores staffs and by the workshop staff is recorded with appreciation.

2. Minerals Utilization.

Studies on the fundamental and applied chemistry of various Australian minerals, with the object of increasing the industrial uses of the derived materials, constitutes the work of this Section. Most of the investigations undertaken have been long-term projects based on such minerals as are well represented in Australia but have been either relatively neglected or exported in the crude state.

The derivatives obtainable from the various minerals that occur in the heavy sands of the eastern Australian littorals have, as previously, received much attention. Many compounds of the lesser-known metals such as titanium, zirconium, hafnium, the cerium group of the rare earths, and thorium, have been prepared from the appropriate minerals and examined. Work previously initiated on chrome iron ores, manganese oxides, graphite and uranium ores has been continued.

Further experience has been gained in certain methods of mineral processing which, on account of their wide applicability, hold some promise of a wider industrial adoption in the future. In this category are included anhydrous chlorinations at elevated temperatures and decomposition of refractory compounds by fluoride reagents.

(*a*) *Chromite.*—Experimental work on the production of chromic anhydride and its derivatives from chrome iron ore by a new acid digestion process has been completed, and progress has been made with the compilation of the data for publication. Considerable industrial interest in the process has been maintained both in Australia and overseas.

(*b*) *Monazite.*—The investigations on the fundamental chemistry of the many components of monazite have been continued and the results incorporated in a scheme for an improved method for the chemical processing of this mineral. An extension of the work on the complex fluorides of thorium has been made concurrently with this work and the ultimate composition of a series of monazite samples from various Australian localities has been determined by a combination of chemical and spectrophotometric methods.

(*c*) *Rutile.*—The properties of titanium nitride have been further investigated, particularly as an ingredient of hard metal compacts in conjunction with various bonding metals. Improved methods of making titanium nitride via rutile and titanium tetrachloride have been developed in the course of this work. Work on heat-resistant paints based on butyl titanate, which was carried out in collaboration with the Defence Research Laboratories, Maribyrnong, has been completed. This work evoked widespread interest both in Australia and overseas, and butyl titanate is now being produced commercially.

(*d*) *Zircon.*—Fundamental studies on the separation of the two elements zirconium and hafnium, which are closely associated in the mineral zircon, have chiefly characterized this programme. Special attention has also been devoted to the quantitative estimation of hafnium in the presence of zirconium.

(*e*) *Uranium Ores.*—Work has been continued on the chemical concentration of uranium from various types of ores and on the concurrent production of useful by-products.

(*f*) *Manganese Oxides.*—Stemming from the investigations on electrical dry cell performance, studies of the structure of the manganese oxide minerals have been continued in more detail and successful attempts have been made to synthesize some of them. Progress has been made in the difficult problem of the classification of these compounds. The correlation of structure with the behaviour of dry cell polarizers has been advanced as a result of this work. Dry cells of good quality have been prepared by the use, as the depolarizer, of an anode mud which is obtained as a by-product in the electrolytic extraction of zinc from its ores.

(*g*) *Graphite.*—A method for the preparation of graphite of high purity has been successfully developed and operated on a small pilot-plant scale. Studies of the grinding of purified graphites have been made at the same time as investigations on the preparation of colloidal suspensions of the mineral. X-ray diffraction and other methods have been employed to classify Australian graphites with respect to those found elsewhere. Fundamental studies on the lamellar complex of graphite and ferric chloride have been continued and a promising method has been developed for the separation of anhydrous iron and aluminium chlorides. The significance of particle size and of liquid retention in graphite used for dry cell manufacture has been investigated.

Throughout the year industrial contacts have been maintained, field inspections of mineral deposits have been made, and a large number of technical inquiries on miscellaneous problems of mineral utilization have been answered.

3. Cement and Ceramics.

(*a*) *Cement Investigations.*—The investigation of the problem of expansive reaction between cement and aggregate in concrete has been continued, and the variables affecting the mechanism of the reaction have been studied and correlated. The general nature of the reaction now appears to be evident, and the knowledge acquired has enabled the Division to assist many public bodies throughout the Commonwealth who have sought advice concerning the desirability of using various types of aggregate, as well as on other matters connected with these investigations. The general question of the functions of the alkali metals, potassium and sodium, in portland cement has also been studied, using cement clinkers of appropriate composition prepared in the laboratory under rigidly controlled conditions. A long-term investigation concerning the effect of surface-active agents on cement and concrete initiated in conjunction with the Building Research Section is still in its early stages; this will be concerned with such effects as air-entrainment and water proofing (*see* Chapter XIII., Section 3).

The Cement and Concrete Association of Australia continues to give financial and active support to these investigations.

(*b*) *Refractories Investigations.*—The factors limiting the life of cement kiln linings have been further investigated by chemical and physical methods, and a sonic excitation method has been adapted to the evaluation of certain mechanical properties of these materials. The physical characterization of the varieties of fire brick used in Australian gas retorts has been completed and attention has been given to the possibility of improving some of these products. In connexion with this work a study has been made of the temperature distribution and fluctuation in an operating gas retort. These investigations of gas retort refractories are being conducted with the active co-operation and financial support of the National Gas Association.

(*c*) *Ceramic Investigations.*—The survey of Australian ceramic materials has been continued and the preliminary mineralogical and ceramic characterization of South Australian clays is nearing completion. In the survey work assistance has been given by the South Australian Mines Department, and the Geology Department of the University of Melbourne has co-operated with the Division in the mineralogical work. The Laboratory, which has been established in Adelaide in conjunction with the South Australian School of Mines and Industries, has investigated a number of short-term problems of interest to manufacturers or Government Departments. In Melbourne a fundamental study of the maturing of whiteware bodies with special reference to Australian materials has been commenced. One aspect of this work has involved the investigation of the effects of heat on silica and in the course of this work a large sample of cristoballite was prepared, at the request of the Bureau of Dental Standards, for use in dental inlay investment powder. The rheological properties of clay and clay-water relationships are also being studied with particular reference to their significance in ceramic practice. Attention is now also being given to the possibility of producing improved saggar bodies from Australian materials.

4. FOUNDRY SANDS.

A comprehensive survey of Australian foundry sands, conducted in collaboration with the Departments of Mines of the various States, has now covered all States on the mainland, testing work in the survey of Queensland sands having been completed during the year.

In an investigation of substitute core binding materials to replace linseed oil in the production of foundry cores, attention has been directed to the use of locally available raw materials. The sulphite process for production of paper pulp is not employed in Australia; thus sulphite liquor, which is used as a core binder overseas, is not readily available. Attention has therefore been given to the use of solutions of lignin produced from kraft process liquors. The use of *Xanthorrhoea* resin, which shows some promise as a core binder, is also the subject of investigation; this resin is obtained from the Australian "grass-tree".

The design of apparatus for testing of cores has been undertaken and progress has been made in developing equipment for the measurement of rate of evolution of gas during the heating of cores. Contrary to previously accepted ideas, it has been shown that in testing the mechanical strength of cores accurate temperature control of the test piece is essential.

The Section provides an advisory service on problems related to moulding sands and general foundry practice; this service has continued to deal with a steady stream of inquiries.

5. PHYSICAL CHEMISTRY.

Investigations of the fundamental principles governing the flotation of minerals and the action of detergents have been continued by this Section, whose activities are directed chiefly to various aspects of surface chemistry.

(*a*) *Flotation Investigations.*—Several aspects of the flotation of minerals have been studied. This work is described in detail in Chapter XVII., Section 5.

(*b*) *Detergency.*—The mechanism of the scouring of wool by means of a soap-soda solution containing an emulsified solvent has been further studied. A detailed description of this work is given in Chapter XIV., Section 5.

(*c*) *The Adsorption of Gases on Solids.*—Measurements of the adsorption of nitrogen at the temperatures of liquid oxygen and liquid nitrogen have been used to determine the surface areas of samples of graphite oxide black and of bentonite for other Sections of the Division. An apparatus to study the adsorption of water vapour on solid surfaces is being designed to provide fundamental information on the flotation process.

6. CHEMICAL PHYSICS.

The specialized facilities of this Section have been placed at the disposal of industry, the universities, and other Divisions and Sections of the Organization. Seven scientific workers from other institutions have worked as guests in the Section for various periods, two of them for the whole of the year. Some of the Section's activities have been directed towards the improvement of existing techniques and the development of new ones.

(*a*) *Protein Structure.*—Fundamental studies related to the Organization's wool research programme have continued. The study of the structure of the wool protein, keratin, and other related fibrous protein systems has proceeded along three main lines, and a senior protein physicist has been appointed to co-ordinate these investigations. The work is described in detail in Chapter XIV., Section 6.

(*b*) *Biological Studies.* — Electron-microscopical studies on several biological problems of importance in medical and veterinary science and in industry have been undertaken in collaboration with scientific workers from other institutions.

(i) *Morphology of Spermatozoa.*—An intensive research on the spermatozoa of the domestic fowl and the bull has revealed many new morphological features and has demonstrated the nature of the differentiation between avian and mammalian sperm in sensitivity of manipulation, an outstanding problem in artificial insemination.

(ii) *Characterization of Bacteriophages of Streptococcus cremoris.*—In collaboration with the bacteriologists of a cheese-manufacturing firm, the bacteriophages which destroy *Streptococcus cremoris,* the microorganism responsible for the production of cheese from milk, have been identified and characterized, and their mode of attack studied.

(iii) *Bacterial Motility and Flagellation.*—The presence of flagella (or tails) has been established as a general feature of motile (or self-propelling) micro-organisms and the evidence suggests, contrary to other views, that the flagellum is the motile organ, being in all probability a primitive muscular unit.

(*c*) *Secondary Phenomena in Electron Diffraction.*—One of the most powerful techniques for the study of crystal structures of solids, many of which are of industrial importance, is that of electron diffraction. Interpretation of the experimental results has been hindered by lack of understanding of some of the phenomena occurring. In particular, the implications of refraction and secondary elastic scattering have not been widely appreciated up to the present. The study of refraction effects, reported previously, has been continued, and an extensive study of secondary scattering and a quantitative interpretation of the effect have extended considerably the scope of electron diffraction.

(*d*) *Investigations of the Surface of Solids.*—The nature of the surfaces of mineral particles after certain ore-dressing operations is of prime importance in their flotation, and the properties of metal surfaces in bearings and cylinders determine their efficiency and wear. A mathematical theory of the stability of the polished layer formed on some metals has been developed and has been confirmed by preliminary experimental observations using electron diffraction methods. This work is being extended to include mineral surfaces.

(*e*) *Lubricating Films on Metals.*—The Section's electron diffraction facilities have been made available to an officer of the Division of Tribophysics to study the relative thermal stabilities of mono-and-multi-molecular layers of lubricants on various metals and to correlate them with the properties of these lubricants in practice.

(*f*) *Molecular Structure Investigations.*—Automatic equipment has been developed for use with the mass spectrometer for the precise measurement of bond-dissociation and ionization energies in volatile compounds. This information is of value in the consideration of molecular structure and chemical reactivity. By the joint use of mass spectroscopy and infra-red spectroscopy it has been possible to contribute to the elucidation of the structures of several compounds.

(*g*) *Mechanism of Light Emission in Electric Discharges.*—The stability and reproducibility of the source of light is a factor of basic importance in the application of spectrochemical methods of analysis in industry or research. During the year a universal source unit for the excitation and control of arc and spark discharges has been constructed and the factors influencing the stability and reproducibility of the light emission have been studied. It has been established that even with reproducible electrical conditions, considerable fluctuations in light intensity occur as a result of the inherent instability of the discharge. The relationship between electrical and spectral-emission characteristics of the discharge are being studied in an attempt to understand the origin of these fluctuations.

(*h*) *Other Investigations.*—Numerous minor investigations, performed at the request of industry, technical institutions, and other sections of the Organization, include—

(i) *Electron Microscopy.*—Examination of various manganese minerals and graphites in relation to dry-cell research; characterization of soil colloids; examination of manganese oxides in relation to soil deficiency problems; calibration of specimens for use as sub-standards in determining the magnification of electron microscopes.

(ii) *X-ray Diffraction.*—Survey of local iron oxides for use in gas purification; analysis of bag-house fume from lead-smelting plant; characterization of local graphite, manganese, and clay minerals.

(iii) *Spectroscopy.*—Spectrochemical analyses of numerous materials by both ultra-violet and infra-red techniques; fluorescence identification of uranium in opaline quartz from local fields; development of analytical methods for the estimation of streptomycin.

(iv) *Mass Spectroscopy.*—Identification of weed-taint compounds in butter; identification of respiration products of apples, of importance in fruit storage problems; various analytical problems.

(*i*) *Instrumentation.*—A large variety of glass, mechanical, and electrical equipment has been designed and constructed for use in this and other Sections of the Division.

7. Organic Chemistry.

The work of this Section has been chiefly directed to the recovery and purification of waxes of potential industrial importance, particularly that recoverable from wool; research on alkaloids having valuable chemotherapeutic properties; and the study of both natural and synthetic resins.

(*a*) *Waxes and Fats.*—The high molecular weight of these materials necessitates the use of specialized equipment for their purification and chemical examination. Equipment for their fractional distillation under reduced pressure now includes a spinning band column which was constructed during the year, a Bowman still, and a modified Stedman column. A microanalytical method has been developed for the direct determination of glycerol in fats and an officer of the Division of Food Preservation who has assisted in this work will later use these techniques for the determination of waxes present in the skins of apples in an investigation of the factors affecting the storage of apples.

(i) *Wool Wax.*—This is essentially an ester wax, but of a very complex nature. Two lines of work are in progress; the examination of the aliphatic alcohols present, and a structural investigation of lanosterol and related compounds. These two groups together constitute about two-thirds of the unsaponifiable matter in wool wax. Saponification of the ester wax to give the mixed free alcohols according to a slight modification of a German process presented no difficulty on a semi-plant scale. Work on the aliphatic alcohol portion so far has shown that this again is a complex mixture. Lanosterol and a number of its derivatives have been prepared in quantity. Further details are given in Chapter XIV., Section 8.

(ii) *Sugar Cane Wax.*—Attempts have been made to discover suitable methods for the removal of the softer components and free fatty acids, and to bleach the resulting hardened wax. A method for the first operation has been devised which does not use expensive organic solvents and by which the acid number of the wax is reduced to a satisfactory value. A number of chemical bleaching agents have been used on the hardened wax and while most of them failed to remove the colour entirely and were extravagant in the amount of oxygen needed to diminish the colour appreciably, one agent has given promising results.

(iii) *Fats.*—The techniques used in the examination of waxes are adaptations of those used with fats. Fats from natural Australian sources have so far received little scientific attention and it is planned to study some of the more attractive ones simultaneously with the work on waxes. This year the composition of the fat from the okari nut has been worked out. The tree, *Terminalia okari*, is cultivated by the natives of New Guinea for the sake of this much prized nut. The large kernel of the nut contains over 70 per cent. of fat, which would be a valuable vegetable butter; it has an iodine value of 60 and a melting point of 32° C.

(*b*) *Reaction Between Acetone and Ammonia.*—Further study of the products of this reaction has led to the isolation of several interesting and highly reactive aliphatic organic compounds. For example, by hydrolysing the product obtained by the action of nitrous acid on the parent pyrimidine compound, new and reactive open chain compounds containing six carbon atoms are obtained. The presence of the highly reactive amino, keto, and oximino groups in adjacent positions suggests that these compounds may have potentialities as intermediates in the fine chemical industry.

(*c*) *Alkaloids.*—The survey of alkaloids obtainable from Australian native plants has been continued and arrangements have been made for new alkaloids to be sent to the National Institute for Medical Research (London) for chemotherapeutic testing.

In collaboration with Mr. Lamberton of the Chemistry Department, University of Melbourne, the structure of the alkaloid acronycidine (a tetramethoxyfuranoquinoline) has been established. This completes the examination of the alkaloids from the rain forest tree *Melicope faraena*: four new alkaloids and one previously known (skimmianine) have been identified. Another new furanoquinoline base, from *Medicosma cunninghamii,* is under examination. The evident versatility of the family Rutaceae has been further demonstrated by the isolation from *Pentaceras australis* of an alkaloid containing sulphur. This substance and two co-occurring alkaloids are derivatives of β-carboline. Other rutaceous species, including *Lunasia amara,* are under examination, while *Gyrocarpus americanus* (Combretaceae) has been shown to contain the known bisbenzylisoquinoline alkaloid phaeanthine.

The survey of Australian native plants has so far been concerned largely with the rain forest flora, but as its scope is extended it will of necessity embrace many of the known or suspected stock poisons. In this connexion, the isolation of the alkaloid lasiocarpine from *Heliotropium europaeum,* suspected of causing liver damage in sheep, is being carried out on behalf of the Division of Animal Health.

(*d*) *Plastics Investigations.*—(i) *Kinetics of the Phenol-formaldehyde Condensation.*—The reaction between phenol and formaldehyde is fundamental to the phenolic resin industry and a study is being made of the kinetics of the reaction. This condensation occurs under conditions which allow formaldehyde to react with itself. This side reaction, neglected by earlier workers, has been found to be more important than previously realized, and the kinetic studies have, therefore, been extended to include the reactions of formaldehyde in the absence of phenol. Work has also commenced on the preparation of tetramethylphenol, which may be more reactive than the "blocked" xylenols commercially available.

(ii) *Aniline-formaldehyde Resins.*—The study of the flow characteristics of these resins alone, or in the presence of various plasticizers, has been determined on the Rossi-Peakes apparatus. Following the release of information regarding commercial production in Germany, an investigation showed that factors involved in the coagulation of the precipitate have a critical effect on the flow of the final product.

(iii) *Natural Resins.*—A resin occurring in certain Victorian brown coals has been examined and shown to be a copal. The sample obtained was dark and its commercial value cannot be assessed until methods for separating the brown coal and resin have been perfected.

Another natural resin occurring as an exudate from the New Guinea tree *Anisoptera polyandra* was found to be of the dammar type, though softer than normal. Its solubility properties make the process of dewaxing difficult: means of overcoming this difficulty are being sought, for dewaxing is a necessary step if the resin is to be of use in industry.

(iv) *Miscellaneous Investigations.*—Tests have been made to compare the flow properties of phenolic moulding powders, as indicated by the Rossi-Peakes machine, with those determined by the standard cup-flow method. The Rossi-Peakes test revealed differences in the resins arising from storage which the cup flow method did not detect.

Mouldings made from ground makita nut (*Parinari laurina*) did not seem commercially attractive since good physical properties could be obtained only by the addition of a considerable amount of binder and the use of a slow moulding cycle.

In continuation of the work on Australian tannins it has been found that the kino exuded by marri (*Eucalyptus calophylla*) also reacts readily with formaldehyde and may give a useful adhesive.

8. Biochemistry.

The Section's activities, which have been almost entirely directed to wool and fellmongering research during the past year, have developed along two main paths in the field of protein chemistry. They have been concerned firstly with the mode of formation of keratin and other constituents of the wool root, and secondly with the fractionation and characterization of certain extra-cellular mould enzymes. The development of this research programme requires the application not only of the conventional methods of biochemistry but also of physical and organic procedures. Thus equipment has been set up and calibrated for the estimation of the diffusion coefficient of proteins by the porous disc method, and for the determination of osmotic pressure with the aid of nitrocellulose membranes. Various amino acids have been prepared from protein hydrolysates and synthesized into peptides by the Fischer and Bergmann methods; these peptides are being used as substrates for proteolytic enzymes and for comparison with compounds isolated from wool roots and wool fibres. This work on wool is described in detail in Chapter XIV., Section 7.

The Section's collection of bacteria, yeasts, and mould has been enlarged during the year by the inclusion of new species and strains, and cultures have been supplied on request to university and industrial laboratories.

9. Chemical Engineering.

During the year the work of the section has been divided between research into the principles upon which certain operations in chemical engineering are based, and pilot-scale plant operation and process development. The basic research projects, each of which alone is making an important contribution to chemical engineering knowledge, have as a group the long-term aim of correlating the molecular structure and physical properties of pure compounds with the process behaviour of these compounds as components of mixtures. This type of work is essential for the further development of methods of chemical engineering design and for the development of new methods of processing.

In the applied field, work has continued on the installation and instrumentation of a wide variety of pilot-scale processing equipment, and the equipment already installed has been extensively used during the year for pilot-plant studies both by officers of the Division and by technologists from industry.

The staff of the Section has continued to provide an advisory service to chemical industry, and to provide facilities and design and construct equipment for other Sections of the Division.

(*a*) *Distillation.*—An investigation designed to determine the equilibrium conditions for the liquid and vapour phases of selected binary mixtures has been continued in an attempt to assign a physical significance to the constants of existing equations, used to express deviations from Raoult's law, and upon which present methods of design of industrial fractional distillation equipment are based. The ultimate aim of this work is to predict liquid-vapour equilibria conditions for binary and ternary mixtures from a knowledge of the molecular structure of the pure components. Considerable effort has been expended during the year in the preparation of pure components and in the development of precise methods of temperature measurement. Liquid-vapour equilibrium data have been determined for the system acetic acid-water.

(*b*) *Solvent Extraction.*—Work has continued on the development of methods for the design of industrial equipment for continuous solvent extraction based on the physical properties and molecular structure of the solute and solvents. Rates of diffusion of benzoic acid in benzene and in water have been determined by interferometric methods. This work is being done by an officer working in the laboratories of the Chemical Engineering Department, University of Sydney.

(*c*) *Physical Properties of Gases and Liquids at High Pressures.*—During the year work has continued on the establishment of a laboratory in the Chemical Engineering Department, University of Sydney, for the determination of the physical properties and behaviour of pure compounds and of binary and ternary mixtures at high pressures. This work will supplement the experimental work in both the distillation and solvent extraction investigations, and in addition the laboratory will collaborate with similar laboratories overseas in the production and correlation of thermodynamic data for industrially important materials.

Equipment is being purchased and installed for the production of pressures of up to 5,000 atmospheres and for the accurate measurement of pressures up to 3,000 atmospheres.

An officer of the Section has recently returned after studying developments in overseas high pressure research laboratories.

(*d*) *Development of Adsorption Processes.*—Work is in progress on the development of a new method of separation based on selective adsorption. Adsorption equilibria and adsorption rates are being studied with a view to developing a continuous industrial process for the separation of chemically similar materials not readily separated by current industrial methods. The process depends on the control by pH adjustment of adsorption and desorption on suitably modified carbon adsorbents. Pilot-scale equipment based on flotation techniques has been developed for continuous and multistage fractional adsorption, and results indicate that the new technique will be applicable in many fields, particularly in the purification of antibiotic and other biological materials. In this connexion an investigation has been undertaken in collaboration with the Commonwealth Serum Laboratories. During the year considerable progress has been made in the development of suitable adsorbents and in particular of modified carbon adsorbents. A theoretical explanation of the mechanism for the adsorption of ions on activated carbons has been developed.

(*e*) *The Study of Fine Particles.*—The behaviour of fine solid particles suspended in gas or liquid media is being investigated with a view to correlating such diverse industrial operations as dust and fume removal, sedimentation, filtration, thickening, and pneumatic conveying. This work has involved the development of methods of preparation, classification, and measurement by interferometry, of uniformly sized and shaped spherical particles. Studies are being made of the dynamics of flow of gases and liquids through beds produced from these accurately sized and shaped spheres, and of the fluid dynamics of systems composed of both dilute and concentrated suspensions of these spheres. This latter phase of the work has direct application in developing the industrial technique of solid fluidization.

During the year the settling rates of fine particles in highly diluted suspensions have been determined by means of a novel type of camera which permits the precise measurement of very low velocities.

(*f*) *Fuel Utilization.*—Because many of the technological problems of fuel utilization are of a chemical engineering nature, steps have been taken to develop a fuel research programme. An officer of the Section has recently returned after studying fuel research developments in England and the United States.

Pilot-scale work has been undertaken on the fluid bed carbonization and on the fluid bed complete gasification of brown coal for the production of gas suitable for use in the Fischer-Tropsch synthetic liquid fuel process. Work is also in progress on the determination of gasification reaction rates in fluidized fuel beds.

XVII. MINERAGRAPHY AND ORE-DRESSING.

1. General.

The importance of investigations for the development of the mining industry and the utilization of Australia's mineral resources has not been overlooked by the Organization.

Mineragraphic work to provide information on the mineral composition of ores has been in progress in Melbourne since 1927. The technique is highly specialized and requires considerable experience, so that it is only rarely that it can be applied by the staffs of operating mines. Current work is described below.

Investigations of ore samples have also been made to provide advice on the most suitable methods of treatment. This ore-dressing work has been undertaken at Kalgoorlie in co-operation with the School of Mines, and at Melbourne in co-operation with the Department of Metallurgy of the University. This work is discussed in Sections 3 and 4 of this chapter.

Work within the Division of Industrial Chemistry on the utilization of minerals is described in Chapter XVI., Section 2. Other work within that Division on the flotation of minerals is dealt with in Section 5 of this Chapter.

2. Mineragraphy.

Twenty-eight investigations have been carried out into the mineral associations of rocks, ores, mill products, and drill cores submitted by mining organizations and institutions. Each investigation was directed to some specific problem relating to the occurrence or recovery of the valuable mineral. Nine of the investigations were concerned with ores that were subjected to experimental treatment in the Melbourne Ore-dressing Laboratory or with the concentrates and tailings resulting from such treatment.

The widespread interest in the composition of the heavy mineral content of detrital sands has resulted in the examination of sands from the Vunda River and Sigatoka River in Fiji, Samurai in Papua, and the Acheron River in Victoria. Examinations have also been made of magnetic concentrates from the beach sands at Bunbury, Western Australia, of white and yellow zircon in electrostatic concentrates, and of opaque rutile in monazite concentrates from the northern New South Wales deposits.

The mineral composition of a large low-grade ore dy at Big Bell, Western Australia, has been investi- ated. The ore body consists of mica schists npregnated with quartz, felspar, tourmaline, and lphides, chiefly pyrite. The distribution of the gold roughout the ore body is known by assay to be fairly niform and the examination of specimens has shown hat the gold particles are always small and occur in he schist, in quartz, in veins cutting arsenopyrite, in trahedrite, and along the contacts of bournonite and ibnite in quartz. The majority of the observed articles were found in specimens containing abundant ibnite, though the gold tends to occur with the rsenopyrite, tetrahedrite, and bournonite in these pecimens rather than with the stibnite. Apart from he gold, interesting features in this ore are the currence of andalusite, the presence of numerous rims f ilmenite around rutile grains, and the association f an arsenical ullmannite with pyrrhotite.

An examination of low-grade gravity tailings from e treatment plant of King Island Scheelite (1947) imited was made to determine its content of free and mposite grains of scheelite. By determining the num- r of free and composite grains in a series of sized frac- ons, using both normal and ultra-violet light, it was und that a very marked diminution in the percentage f composite grains containing scheelite occurs between he +52 mesh and the +72 mesh fractions. It was und that the size of the average scheelite crystal is ss than the mesh of the 52 screen and greater than he mesh of the 72 screen, so that crushing to this rain size is critical to the liberation of the scheelite. uch information is obviously of value to the mill perator.

Some samples of Yerranderie silver lead ore were mong the material examined for the Melbourne Ore- ressing Laboratory. The examination disclosed eplacements of pyrite and arsenopyrite by galena and trahedrite and sometimes by chalcopyrite before the evelopment of galena. Minute particles of dyscrasite nd native silver were observed in galena, and some solated areas of sulphide in quartz were found to be ntricate aggregates of galena, chalcocite, bornite, halcopyrite, stromeyerite, native silver, tetrahedrite, rsenopyrite, and pyrite. If the Yerranderie mines ome into production again the ore will provide an nteresting study of copper and silver enrichment.

The investigations have been facilitated by contribu- ions from a number of mining companies through the ustralasian Institute of Mining and Metallurgy. he University of Melbourne has also assisted by roviding expanded laboratory accommodation in the ewly completed extensions of the Geology Department.

3. Ore-dressing Investigations at Kalgoorlie.

At Kalgoorlie, where investigations are being carried ut in co-operation with the School of Mines, 29 amples, of which 19 were samples of ore, of tailings, r of mill products associated with gold mining, were eceived for investigation. Some were submitted erely for routine tests while others were submitted o determine a method of treatment. Four samples f lead ore, or concentrates, were received—two from Vestern Australia and two from outside the State. ome work was done on refractories. A kyanite ore as received for beneficiation tests and a refractory rick was submitted for examination. A sample of ailings was submitted to determine the amount of assiterite present. For all samples, the information enerally wanted was either a method of treatment or nformation to assist in some section of the treatment lant. The work of the laboratory has been andicapped by sickness among the staff, and later by hortage of staff.

4. Ore-dressing Investigations at Melbourne.

At Melbourne, where work is carried out in co-operation with the Department of Metallurgy of the University, 29 reports were issued. Of these, 13 relate to gold ores and tailing dumps, 6 to beach sands, 4 to lead-silver ores, and 3 to copper ores. Increased attention to gold dumps has not as yet resulted in much new commercial development. Increased interest in lead ores reflects the high price prevailing for this metal.

Selective flotation of a copper ore from Laloki, Papua, has been shown to be greatly improved by pre-aeration with lime and chemical oxidizers. During this investigation useful and stimulating contact was maintained with Mr. C. G. McLachlan, General Superintendent of Mills, Noranda Mines Ltd., Canada.

A four-stage process for selective soap flotation of zircon from rutile, ilmenite, and quartz has been developed and details have been published. Investigation of the electrostatic separation process has made substantial progress. A mathematical expression relating voltage with displacement of the median of a stream of sized mineral particles was developed. Using a separator designed and built in the laboratory, this relation was confirmed experimentally. The material of which the earthed plate is made and the lapse of time since it was polished have been shown to have an important influence on separation. The electrostatic behaviour of several minerals has been examined and encouraging preliminary results have been obtained in separating natural resin from Yallourn brown coal.

5. Flotation Investigations.

A factor of considerable importance in determining the capacity of a flotation cell is the interval of time which elapses between the collision of an air bubble and a mineral particle, and their adhesion. An investigation of this induction period, and of the factors which influence its duration, has been commenced.

In the flotation of topaz, interference is caused by the presence of calcium ions. The reason for this has been determined, and this knowledge should be of value in the flotation of other non-sulphide minerals. A fundamental study designed to provide a background of information concerning the factors which determine froth formation has been commenced. The importance of such information lies in the general dependence of the selective flotation of minerals upon suitable frothing conditions and it is specifically required for the current investigation of the flotation of the industrially important tungsten mineral, scheelite. The adsorption of collectors on minerals which enables bubble attachment to take place has been the subject of further study. In this work the use of pure flotation reagents is essential and some time has been devoted both to their preparation and to the development of chemical and physical criteria of their purity.

XVIII. FUEL.

1. General.

Attention has been given for some time past to an extension of the activities of the Organization to include research on fuel. Following the visit to Australia of the late Professor T. David Jones and the recommendations of the Coal Utilization Research Committee, a decision was made to concentrate initially on work on the microstructure of coal and a survey of the properties of Australian coals.

The Organization's work in this field is to be undertaken mainly by its Coal Research Section (previously called the Coal Survey Section). Work on brown coal deposits is being started in collaboration with the

Botany Department of the University of Melbourne. Work on chemical engineering aspects of carbonization is in progress within the Division of Industrial Chemistry.

2. Coal Research Section.

An area of some thirteen acres at Delhi-road, North Ryde, New South Wales, has been chosen as the site on which to erect the Section's laboratories. Temporary offices have been provided and were occupied in March, 1949.

Plans have been prepared for semi-permanent single-storey buildings for laboratories and workshops. Collection of the necessary apparatus and equipment is well under way, and a start has been made on the establishment of a comprehensive library dealing specifically with fuel research.

In its survey of the chemical and physical properties of coal, the Section will work in close collaboration with the various Coal Boards, State Departments of Mines, Geological Surveys, and other authorities. The necessary staff for this work is now being appointed.

An investigation into the gas-, coke-, and by-product-making properties of Australian coals is being undertaken in co-operation with the National Gas Association, using equipment located in the laboratories of the Association in Melbourne.

An officer who is to undertake petrological investigations returned from training overseas during December. His work to date has been concerned mainly with a survey of the literature and with the recording and correlation of borehole logs.

The Section has taken an active part in the work of various Committees of the Standards Association of Australia.

3. Brown Coal Deposits.

At the Botany School at the University of Melbourne, fundamental studies are being made on a co-operative basis on fossil and living pollen of the tertiary flora of Australia, with particular reference to brown coal deposits. This involves the formation of a library of living pollen, but the chief object of the work is to determine whether pollen analysis can be used in solution of stratigraphic problems.

4. Fluid Bed Carbonization.

Because many of the technological problems of fuel utilization are of a chemical engineering nature, work in the field of fuel research has been started in the Chemical Engineering Section of the Division of Industrial Chemistry.

Pilot-scale work has been undertaken during the year on the fluid bed carbonization and on the fluid bed complete gasification of brown coal for the production of gas suitable for use in the Fischer-Tropsch synthetic liquid fuel process. Work is also in progress on the determination of gasification reaction rates in fluidized fuel beds.

XIX. PHYSICAL METALLURGY.

1. General.

The Organization has not yet developed an extensive programme of metallurgical investigations, but a small co-operative Section of Physical Metallurgy has been established in the Research School of Metallurgy at the University of Melbourne under the direction of the Research Professor of Metallurgy. The work of the Section is described in the remainder of this Chapter.

A considerable programme of work on metal physics is in progress within the Division of Tribophysics and is outlined in Chapter XX., Section 3.

Work on foundry sands carried on within the Division of Industrial Chemistry is reported in Chapter XVI., Section 4.

2. Titanium and its Alloys.

In the previous year methods of preparing titaniu were developed. In the year under review it has bee found how the metal might be most efficiently fabri cated. It is surprisingly ductile, and by continue fabrication at room temperature the tensile strengt can be raised from 30 to 90 tons/sq. in.

The effect of alloying with other elements, particu larly iron, is under study. This investigation is com plicated by the change in atomic structure which th metal undergoes at about 883° C. The structur changes from a hexagonal packing of the atoms t a body-centred cubic structure at the higher tempera tures. This allotropic change is being studied in detail Some of the main effects of iron, however, are becomin clear. Increasing additions depress the temperature o the allotropic change. The iron is more soluble in th high-temperature form. These facts have been utilize to obtain the best conditions for fabrication.

In studying the allotropic change of the metal and it alloys a new technique has been developed which i likely to have wide application to the study of phas transformations generally in alloys. The method con sists of determining the hydrogen pressure at differen temperatures when a very small amount, some 0.00 atomic per cent., is dissolved in the metal. The advan tages are that the method gives results more rapidl and accurately than the usual techniques, and require only about 0.5 g. of material, which need have n special shape. An apparatus has been developed whic permits a large number of specimens to be examine at the same time.

3. Lead and its Alloys.

Previous extensive investigations carried out at th University of Melbourne have shown that the cree characteristics of lead are profoundly modified b small additions of other elements. The object of th present programme, which is being carried out in clos collaboration with the Baillieu Laboratory of th University of Melbourne, is to study the effect of suc additions systematically for a series of elements. Th object is partly technological, but also of fundament interest in that an attempt will be made to find wh modifications in structure produce the changes i mechanical behaviour.

The first stage has been to secure and examine t properties of a very high purity lead, and to standardi conditions in the preparation of the material which a known to affect the rate of creep. The difficulty is th the process of creep is extraordinarily sensitive factors which would be negligible in normal more rap straining. This work is in progress, together with preliminary survey of the effects of a number additions.

4. Strength and Structure of Metals.

The problems in this field are emphasized by mode trends in engineering which demand metals capab of serving under increasingly complex conditions stress and temperature, for example, in gas turbine a aeroplane parts. It has become more and mo difficult to predict how soon metals will fail und many circumstances because of the limited conditio under which their mechanical properties have be studied under laboratory conditions.

The immediate object of the present work has be to obtain information on the changes in intern structure when a metal is deformed under a series very different conditions. The changes of speci interest to the Section are those which affect t apparent strength.

Studies are being made of the atomic elasticity metals (by X-ray diffraction methods), of changes the structure of a metal loaded at elevated temperatu such a way as to produce slow continuous deforma- on, and of the changes in structure of a metal forcibly rained at a pre-determined constant rate at various mperatures.

Other work is in progress on the behaviour of metals nder alternating stresses, which lead to the so-called rocess of failure by fatigue.

Another line of research has been into the changes hich occur as a deformed metal is progressively heated the point of recrystallization. Some new observa- ons by X-ray diffraction show a series of intermediate hanges prior to recrystallization. They make it ossible to isolate the factor which appears to be most irectly responsible for the instability leading to ecrystallization.

XX. TRIBOPHYSICS

1. General.

Division of Tribophysics.—The work of this Division as developed from work on lubrication and bearings nitiated during the recent war. These lines of investigation have been continued and extended to include undamental studies in metal physics and work on eaction kinetics. The present chapter outlines the ype and scope of the work of the Division, which have ot changed during the past year. Expansion in any eld of work is precluded by cramped conditions and would necessitate reduction of activity in another irection.

The temporarily suspended work on the mechanism f explosion has been taken up again on a broader basis, he emphasis now being laid on reaction kinetics in eneral.

Co-operation with the Chemical Physics Section of he Division of Industrial Chemistry in the work on the properties of monolayers continues and has developed o mutual satisfaction.

The hope that the Division's new building would be begun during the second half of 1948 has not been ulfilled. The contract has been signed and building will be commenced as soon as materials become available. The Division is deeply indebted to Professor Hartung for his continued hospitality, on which it has had to depend much longer than anticipated.

The Division has continued to give assistance and advice on bearing and lubrication problems and in the fields of electrolytic polishing, metallurgy, and electronics to a wide variety of industrial firms, Government organizations, and University departments. Members of the Division are acting on various technical committees, in particular the Engineering Group Committee. The metallurgical colloquia are being successfully continued in conjunction with the other metallurgical groups and are now among the well-established metallurgical events in Melbourne.

A graduate of the University of Cambridge who received a Goldsmith Dominion Travelling Scholarship is now working with the metal physics group.

The active co-operation of the Physics, Metallurgy, and Engineering Departments of the University of Melbourne has continued during the year.

2. Friction and Lubrication.

(*a*) *Friction.*—Work on the nature of metallic friction has been continued. It has been found that sliding metals are deformed for a considerable depth below the surface of contact and an account of this work has now been published. Using taper section methods, a further study is being made to determine what fraction of the work involved in sliding friction is expended in deformation. It has been found that the work hardening in the immediate surface layer is extremely high and is sufficiently great to allow some recovery of the mechanical properties of the metal. The degree of cold work at the surface therefore reaches a saturation value. Further sliding experiments will be attempted under conditions where the minimum of recovery can occur.

Friction is also affected by the type of surface irregularities. For surfaces with a regular profile this effect can be estimated and experiments are in progress comparing the expected values of friction with the properties of specially constructed surfaces.

(*b*) *Lubrication.*—(i) *Lubrication by Thin Films.*—Work has been concentrated mainly on the electron diffraction investigation of the structure and properties of molecular films of long chain polar compounds deposited by the Langmuir-Blodgett method on polished metal surfaces. The structures of films of stearic acid deposited on copper (reactive) and on platinum (inert) have been recorded over a temperature range from 20° C. to 150° C.

Results with copper indicate that as the temperature of the metal is raised, reaction between the metal and stearic acid is accelerated until at about 85° C. actual crystals of copper stearate can be detected. The crystals continue to grow and become well oriented until at about 125° C. they suddenly disappear.

With platinum, on the other hand, no apparent reaction takes place and multilayers of stearic acid exist on platinum in the form of an extended crystal. On copper such multilayers appear to exist in the form of unassociated molecules standing normal to the surface.

(ii) *Electrical Properties of Thin Films.*—The changes in surface potential produced by the deposition of monomolecular layers of various long chain polar compounds on highly polished metal surfaces have been studied. As expected from the frictional properties, films of stearic acid on platinum behave quite differently from those on active metals such as copper and cadmium. An apparatus has been designed for the continuation of the experiments *in vacuo*.

(iii) *The Composition of Monolayers.*—The composition of films of stearic acid deposited from aqueous substrates containing calcium or barium ions can be controlled by varying the pH of the substrate. In view of the importance of obtaining layers of known composition for work on the boundary lubrication of metal surfaces by mono- and multilayers, this technique is being applied to solutions of other ions such as copper, silver, iron, &c.

(iv) *Silicone Lubricants.*—The preparation of monocetyl silane in reasonably good yield has been achieved. The lubricating and other properties of cetyl silicone films produced on metal surfaces have been examined. The formation of similar films on an aqueous surface by spreading a benzene solution of the silane appears to be possible at least for the cetyl silane, and the films so formed have been investigated using a Langmuir surface balance. The work on silicones is temporarily held up owing to shortage of staff.

(v) *Interfacial Potentials.*—Adsorption from solution is of interest in connexion with the lubrication of metal surfaces by solution of long chain polar compounds. A convenient method of measurement of the variation of adsorption with temperature and concentration based on the measurement of interfacial potential is being developed.

(vi) *Piston-ring Lubrication.*—A capacity-type pressure indicator has been fitted to the test engine which permits simultaneous observation on a double-beam cathode-ray tube of the indicator diagram and oil film conductance. This required major alterations in the existing amplifier units, causing considerable delay in the experimental programme, but tests already carried out have shown that high engine loads cause apparent increased breakdown of the oil film. A permanent record of the cathode-ray traces has been obtained by the use of a continuously moving film.

(vii) *Bearing Testing.*—Running tests have shown marked variations in the performance of bearings due to extremely small dimensional errors. Different machining procedures have been tried out and it is expected that consistently accurate bearings will now be produced. Some other random causes of error have been eliminated during the year and running tests are continuing. A paper dealing with the design and performance of the frictional balance used in this work was presented at the Australian and New Zealand Association for the Advancement of Science meeting in January.

3. METAL PHYSICS.

(*a*) *Plastic Deformation and Strength.*—(i) *Effect of Surface Conditions on Plasticity and Strength.*—It is known that a change in surface conditions may alter the observed strength of metallic single crystals. This is ascribed to a changed influence on the cracks and flaws present at the crystal surface which determine the strength. Russian workers have claimed that surface-active substances adsorbed on crystals lower their strength markedly. This work has been checked with single crystals of tin of known orientation. Tensile tests at various rates of stressing and measurement of the electrical resistance and the rate of deformation at constant load have not confirmed the results published by the Russian workers. It is hoped that further experiments on the effect of surface conditions will explain the discrepancy.

(ii) *Measurement of Energy Stored in a Metal during Plastic Deformation.*—The calorimeter constructed to measure the specific heat of a deformed metal as a function of temperature has been tested and various alterations were found necessary.

(iii) *Mechanism of Twinning.*—Some metals deform by "twinning", i.e., by a bulk movement of atoms giving a zone with an atomic orientation which is a mirror image of that of the remainder of the crystal. Single crystals have been prepared to study the effect in zinc by shearing the metal in the same direction as the known direction of twinning.

(iv) *Interaction between the Crystals at the Grain Boundaries.*—The calculation of the properties of polycrystalline metals is based on the belief that they are governed by the properties of the individual crystals. The work described in this section has been undertaken partly as a result of criticism of a theory published by G. I. Taylor in 1938 and was discussed extensively with him during his recent visit to Australia

All previous observations on the anisotropy of plastic properties have been made on the surface of the specimens. These were not necessarily relevant to Taylor's theory, which referred to the behaviour of crystals entirely embedded in other crystals. With the use of a newly developed etching technique it has now been possible to observe details of the deformation in the interior of metal specimens. The investigation, which is being prepared for publication, has shown that the inhomogeneity of deformation previously observed at the surface is also very large in crystals surrounded by other crystals; this means that such a crystal does not deform as a unit but the deformation at its centre is different from that occurring near its boundaries. Some details of the development of slip in crystals have also been obtained from observations of slip lines, their change in direction, and behaviour near grain boundaries. Some of these results have been communicated to a discussion on the appearance of slip lines published in *Metals Technology,* August, 1948.

The work on the deformation and recrystallization of two-phase silver magnesium alloys has been completed and is being prepared for publication. The most interesting results obtained may be summarized as follows:—the effect of the relative proportions of the phases—as the volume fraction of the hard phase is increased the deformation per unit volume of this phase also increases until both phases take part in the deformation to an equal extent; precipitation relieves stresses produced by cold work in the matrix in which it occurs and the recrystallization temperature is raised accordingly.

(v) *Deformation at Low Temperatures.*—Preliminary work has been carried out on wire-drawing at low temperatures using a modified drawbench. Copper and mild steel wires have been successfully drawn at liquid-air temperature using tungsten carbide dies. An improved apparatus is being constructed.

It is intended to estimate the importance of recovery during working processes by measurement of the electrical resistivity.

(*b*) *Phase Changes in Metals.*—(i) *Diffusion.*—The work on diffusion of cobalt in iron has not progressed much further owing to experimental difficulties which, it is expected, will be overcome in the near future.

The first part of the programme of research on the rate of self-diffusion in tin has been completed and is being prepared for publication. The rate of diffusion in a direction parallel to the tetragonal axis is smaller than that in the direction perpendicular to this axis, the activation energy for "perpendicular" being about half that for "parallel" diffusion. The theoretical implications of these results are being worked out.

(ii) *Order-disorder Transformations.*—In the interpretation of the results of previous experiments the suggestion was advanced that short-range order in an alloy has a large effect on the electrical resistivity. Experiments carried out to test this suggestion have shown no effect of the required magnitude.

In the course of the work an ordered structure in α-phase silver magnesium alloys has been found. The existence of this ordered phase had been predicted theoretically but denied on experimental evidence by various workers. The exact location of the atoms in the structure is being worked out by X-ray analysis.

(iii) *Solidification of Copper-bismuth Alloys.*—Cooling curves taken during solidification of certain copper-bismuth alloys have shown an anomaly. In order to investigate this an apparatus has been constructed for the automatic recording of differential cooling curves of metal specimens. By this means it is possible to determine the temperature of phase changes and also the approximate energy changes involved.

4. REACTION KINETICS.

An officer having recently returned from Sir Cyril Hinshelwood's laboratory at Oxford, work is being commenced on the kinetics of combustion and oxidation reactions. Apparatus is being assembled and a start has been made on the problem of the differing reactivities of organic compounds towards oxygen.

Work on the mechanism of explosive reactions has not yet been resumed owing to lack of space. However, a study is being made of the engineering problems involved in the construction of a high-speed rotating mirror camera, which will be used to investigate the mechanism of propagation of explosions. A rotary vacuum seal is being developed to permit the mirror to be run *in vacuo,* and the power requirements of the mirror are about to be investigated on a test rig. A theoretical study has been made of elastic deformations in the mirror surface due to centrifugal forces.

5. MISCELLANEOUS.

a) *Electronics*.—The work of the electronics group y be divided into two sections: (i) the work that the up undertakes in conjunction with other groups in Division, and (ii) their own project, which is an estigation into the method of measurement of X-ray ensities with Geiger counters.

i) Among the many pieces of electrical apparatus istructed the following may be mentioned:

A new electrical device has been made for the work piston-ring lubrication which permits the simul- ieous study of piston-cylinder contacts and pressure ide the cylinder.

A number of sensitive temperature controllers have en built for use in the experiments on diffusion and ecific heat.

In addition, general assistance and advice in the astruction and setting up of electrical apparatus in e Division has been given.

(ii) For the work on X-ray intensity measure- ents, an X-ray set using full-wave rectification and ilips sealed-off tubes has been assembled. After periments with a number of types of high-voltage wer supplies suitable for use with Geiger counters, e final power supply units have now been constructed. ne set of Decade counting units has been completed id the second set is under way.

Preliminary measurements of line intensities are ing made.

During the developmental work on the apparatus a mplete Geiger counter unit was constructed and it is ing used in the measurements of the rate of self- ffusion in tin.

(*b*) *Electrolytic Polishing*.—The revised edition of e report on electrolytic polishing has been issued. he wide interest in the report shown by industry and overnment organizations and the frequent inquiries ceived indicate the increasing use of this method of rface treatment in industrial engineering practice id in research laboratories.

(*c*) *Australian Bentonites*.—The rheological proper- es of bentonite suspensions have been investigated, sing the "moving plate" method. If a thin plate is nmersed in a gel and a gradually increasing force pplied to it so that it tends to move in its own plane, oth the elastic properties and the flow value of the gel an be measured. The effects of various factors on ie results obtained have been examined for suspensions f bentonite in water. Particular attention has been aid to the very large effect the plate material has on ie measured flow value, but no complete explanation as yet been found. A report on the work is being repared. Preliminary experiments have been made test the method using iron oxide gels, and further ork along these lines has been planned.

XXI. METROLOGY.

1. GENERAL.

Accurate measurements are essential for efficient and conomic methods of production in most industries. he equipment used for this purpose must be checked nd calibrated from time to time against working tandards of measurement and these in turn against ational standards.

The Organization is the custodian of the Common- ealth Standards of Measurement of the various hysical quantities. These are maintained in its ational Standards Laboratory by the Divisions of etrology, Physics and Electrotechnology. Its Division f Metrology is responsible for the Commonwealth tandards of Measurements of length and mass and associated physical quantities. The Division engages in research into matters concerned with precision measurements in this field and into applied mechanics.

Division of Metrology.—The work of the Division during the past year is outlined in the remainder of this chapter.

Rearrangement of the work of the Division into standards, research, and test work has had very good results. The return of one of the staff from overseas, where he had been assisting in research work at the National Physical Laboratory, permitted a long-awaited opportunity of attacking problems of fundamental interest to the Division. The complete absence of response to advertisement has, however, seriously delayed the general programme of the Division. Further, a lack of first-class instrument designers has meant that an undue proportion of the time of the staff has to be given to such work.

The Weights and Measures (National Standards) Act 1948 placed on the Laboratory the responsibility of maintaining the Commonwealth legal units of measurement of physical quantities. A considerable amount of attention has been given to meeting the Division's statutory functions and disturbance has been caused to the accommodation and equipment of the Division in preparing foundations for comparators for this purpose. The air-conditioning equipment in the new wing is not yet functioning satisfactorily and is in the hands of the Works Department.

The American Petroleum Institute has approved this Division as a testing authority for a limited range of A.P.I. master screw gauges. Equipment is in course of design to permit an extension of the range to be sought if warranted.

One member of the staff is overseas, spending his time between Cambridge University and the National Physical Laboratory.

2. MEASUREMENT OF LENGTH AND ASSOCIATED QUANTITIES.

Line standards have been received on which the Commonwealth legal measurement standards will be based. With the installation of the universal comparator, all measurements will be determined in terms of Commonwealth Line Standards.

(*a*) *Universal Comparator and Geodetic Base*.—Both the universal comparator and the equipment for the geodetic base are now on the water. Construction of the foundations for the universal comparator is well advanced and will be completed before its arrival. Work has begun on the foundations of the geodetic base. Much time has been spent on planning its installation.

During the year, various scales and surveying tapes have been calibrated for other organizations, using less accurate and more cumbersome methods than will be available with the new equipment.

(*b*) *Use of Graphical Squares*.—In the intercomparison of standards of all types, much use is made of so-called graphical squares for the calculation of the quantities required. The use of such graphical squares is well known and gives not only improved estimates of the quantities concerned but also residuals which are a guide to the accuracy attained in the intercomparison. During the year much time has been spent on the theory of the method and on the derivation of formulae permitting the exact calculation of the accuracy from the residuals for the two types of graphical squares.

(*c*) *End Standards*.—The normal programme for the maintenance of end standards has continued with some disorganization due to failures of electricity supply affecting temperature conditions. Reference end standards have been maintained partly by interferometry.

(*d*) *Interferometry.*—A series of important projects has been started. The programme covers four fields: development of new and improved methods of routine standardization of length and angle by interferometry; development of methods for determining large lengths and long distances; fundamental studies in surface finish, surface structure, and surface damage of metal surfaces in contact; and fundamental work on wave-length standards.

(i) *Calibration of Angle Gauges.*—A new method of calibrating angle standards by interferometry is proceeding. Angles ranging from 3 seconds to 1 minute have been measured and analysis of measurements on the 3-second standard gives a standard deviation of better than 0.2 second. The method is showing up significant variation in angle over the surfaces of the standards and is confirming deficiencies found in auto-collimation methods.

(ii) *Kösters Interferometer.*—A Kösters type interferometer is being designed for the measurement of lengths up to 300 millimetres. An extension of the range of the instrument will depend upon satisfactory sources of radiation becoming available.

(iii) *Surface Finish Standards.*—Measurement of steps in glass surface finish standards, by the use of multiple beam Fizeau interference fringes in transmission, is showing high promise. The order of precision of this absolute method in preliminary measurements is 10 Angstroms (0.001 micron). Phase loss effects are being investigated.

(*e*) *Surface Finish.*—Work has continued on the production of standards of surface finish used for the calibration of instruments for measuring surface finish. The best standards overseas consist of grooves etched in glass after cutting through a resist. Improved grooves were obtained by employing an undercoat of metal under the wax resist.

The newer method developed in the Division has proved quite successful. The wax resist is placed on a slip gauge surface and after a series of rulings have been cut from the wax, chromium is deposited on the exposed surfaces of the slip gauge. The surfaces of the deposited metal are then lapped parallel to the undersurface by a technique developed in the Division.

At the request of a large engineering organization, attention was given to the production of a replica of a surface of a piece of equipment too large to be brought to the surface finish measuring instrument. Conditions for the use of various types of plastic were investigated and results accorded with those published overseas as work neared completion.

(*f*) *Graticules.*—Following directly on the work on surface finish standards, an interesting method was developed for the production of graticules in conjunction with the Radiophysics Vacuum Laboratory. This method consists of deposition of an evaporated layer of metal such as zinc on a glass base, cutting the lines to the pattern desired in the finished graticule, deposition of a layer of chromium over the whole surface, and preferentially dissolving the first metal (that is, the zinc) deposited. The residual pattern is that of the chromium filling the lines cut through the original zinc. The edges are sharper and the chromium is very adherent to the glass.

(*g*) *Temperature Control in Measuring Rooms.*—An electronic proportioning controller developed by the Division of Physics has been applied to the control of temperature in the end measuring room. Very satisfactory results were obtained, the variations in temperature being reduced from about 1° C. to 0.2° C The possibility of its application to the tape corrido for control of the temperature of the geodetic base is now being examined, and it is proposed to apply the system to other laboratory rooms where good contro of temperature is essential.

(*h*) *Electronics.*—Various aspects of measuremen of length by electronics are being investigated. A strain meter is being developed in which the frequency of a stable thermionic valve oscillator is used as the criterion of length. It is characteristic of this type of equipment that high sensitivity may be easily obtained The useful sensitivity, however, is limited by the electrical stability of the circuits. Important features of the present equipment are that critical oscillatory circuits are designed for high-frequency stability and are contained in isothermal chambers. High-tension and low-tension power supply voltages are stabilized.

A number of applications involving the automatic control of electric power in a load have arisen in the Division. The use of transductors in this application has been investigated and the behaviour studied of some available magnetic materials under the influence of superimposed alternating current and direct current fields. Nomograms have been designed to facilitate the specification of the magnetic circuit for a transductor when the desired maximum power to the load and control range are known.

(*i*) *Measurement of Gears.*—During the year, two large hobbing machines for turbine-drive gears were installed at the Bendigo Ordnance Factory by the Department of Supply and Development. On behalf of the Department of the Navy, the machines and trial gears hobbed on the machines have been tested for conformity to specification. Equipment used for the measurement was made in the Laboratory Workshop, much of it to the design of the National Physical Laboratory. During the course of the work, a novel test was developed and applied to the measurement of one of the errors of each of the machines. As a result of this series of tests, various adjustments are being made to the machines.

(*j*) *Calibration Services.*—The usual functions of a calibration and consultation service to industry has been maintained during the year. New equipment has been installed to provide speedy and accurate service to industry.

3. MEASUREMENT OF MASS AND ASSOCIATED QUANTITIES.

(*a*) *Standards.*—The full reverification of the standards of mass which is usually made in May and June has been deferred until the hydrostatic balance is available for the measurement of the volume of certain standards.

Two each of 1-kilogram and 1-pound standard weights and one 500-gram standard weight, all of nickel-chromium alloy, were received during the year. The values obtained for these weights in terms of the Laboratory Standards agree very well with the values reported by the National Physical Laboratory.

(*b*) *Instability of Screw Knob Weights.*—Further evidence has been obtained of the effect of the adjusting material on the instability of screw knob weights. Five sets of rhodium-plated brass screw knob weights are now under observation and, when sufficient data have been obtained, it is proposed to open up the weights to investigate the conditions of the material in the cavity.

(*c*) *Materials for Mass Standards.*—The investigation of the materials which might be suitable for the production of reference and working standards of mass indicates that the nickel-chrome alloy, 80 per cent. nickel and 20 per cent. chromium, and austenitic ainless steel are probably superior to any materials her than the noble metals. An investigation was ade into methods of producing a satisfactory surface ish on these materials. This has been successfully ncluded in the case of the stainless steels and the anufacture of the weights will shortly be commenced.

(*d*) *Investigations into Errors in Balances.*—The vestigations into the errors associated with balances ave led to a discrepancy between theoretical and perimental results which is being further investigated.

(*e*) *Residual Films in Glass Measuring Vessels.*—he thickness of residual films of liquid in glass easuring vessels is being investigated with a view determining the errors introduced into the measure- ent of volumes of liquids whose viscosity differs from at of water.

(*f*) *New Instruments.*—A new type of fully auto- atic adjustable pipette has been developed and a odel made up for experimental purposes. Another ovel instrument developed as a result of an inquiry om industry is for the indication of the volume of quid in a storage tank. The main features of this istrument are that there is no possibility of any liquid scaping should the indicator be damaged. This renders suitable for use on tanks of inflammable liquids.

(*g*) *Volume-Measuring Equipment.*—A number of equests have been received from industry for informa- ion relating to the design of special volume-measuring quipment. In most cases, a full specification for the quipment has been supplied.

(*h*) *Residual Films.*—An investigation is being ade into the thickness of the residual film of liquid emaining in glass measuring vessels after emptying nd draining. The results indicate that drainage is ractically complete after a period of 30 seconds in he case of water and, as would be expected, the thick- ess of the film is a function of the viscosity of the iquid.

(*i*) *Hydrostatic Balance.*—The demand for the ccurate determination of densities and calibration of ydrometers is increasing. The equipment for this ork has been ready for installation for some time but he required accommodation has only just become vailable. When this equipment is installed, the ivision will be independent of any material standards f density as all measurements will be made directly n terms of the density of pure water by weighing.

4. Applied Mechanics.

The development of the National Association of Test- ng Authorities has now reached a stage where the first aboratory has applied for registration. The Division s assisting in the work of examining laboratories nd the calibration of their equipment.

(*a*) *Co-ordination of Testing.*—As in the past, a alibration service has been provided for physical test- ng machines and certain engineering instruments, he work in the main being done on behalf of the nspection Authorities of the various services. This ork has included examination of test houses in ueensland and in New South Wales.

(*b*) *Vibration.*—The work in the field of vibration as been of a limited nature owing to the absence over- eas of the officer mainly concerned. The calibration haracteristics of the three types of vibration pick-up nit developed by the Division have been investigated, easurements have been made of vibrations in a room n which it is proposed to install delicate instruments, nd assistance has been given to a commercial firm in he calibration of an imported pick-up unit.

(*c*) *Wire Resistance Strain Gauges.*—A technique as been developed for the manufacture and application f wire resistance strain gauges. Although some stress analysis has been done by this method, the main work has been the development of force-measuring units for special applications.

(*d*) *Stress Analysis.*—It is intended to increase the Division's facilities for stress analysis, and apparatus for photoelasticity investigations is being made jointly by the Division and the Aeronautical Research Laboratories of the Department of Supply and Development, certain optical parts being provided by the Defence Research Laboratories. It is expected that the completed apparatus will be available for use in the near future.

(*e*) *Low-Energy Impact Tests.*—Apart from the work along such definite lines as the measurement of force, pressure, angular speed, and vibrations, for which permanent equipment is available, assistance has been given in the deriving of techniques for special tests, including the development of equipment for making special low-energy impact tests and the design of apparatus for testing wheel type glass cutters.

(*f*) *Hardness Testing.*—Arising out of hardness tests on small steel balls, mentioned in a previous report, an expression was derived for the indentation area allowing for the curvature of the spherical surface, to check certain suspect figures in a standard specification. A report of the work was forwarded to the Authority concerned, who have since replied confirming the suspected errors.

XXII. PHYSICS.

1. General.

The Organization is engaging in many aspects of physical research within various of its Divisions. The present chapter is concerned with the work of the Division of Physics, which forms part of the National Standards Laboratory.

Division of Physics.—The Division maintains the Commonwealth Standards of Measurement of heat and light and associated quantities and the primary electrical standards. It is engaged in research associated with precision measurements in these fields and on heat, light, and the properties of materials.

In the past year a considerable amount of assistance has been given to industry in the form of advice and the investigation of problems, and members of the staff have assisted in the work of the National Association of Testing Authorities and the Standards Association of Australia by serving on committees of these bodies.

During the year 221 certificates, reports, and statements of examination were issued.

One senior member of the staff has been abroad during part of the year inquiring into work in solar physics, photometry, colorimetry, and optics. Two other members of the staff are abroad studying fields of physics of importance in artificial rain production and in low-temperature research. There has been great difficulty in filling vacancies for research physicists, particularly in wool research.

2. Heat.

The work of the Heat Section has been divided between the development and maintenance of standards, short-term investigations for industry, and two major research projects: the study of phenomena associated with natural precipitation and the installation of equipment for research at very low temperatures. The scope of the work on precipitation has been broadened during the year to include investigations on the growth of water droplets falling through a mist of smaller droplets, and the investigations on ice crystal formation and growth have been continued. A considerable amount of auxiliary equipment has been constructed for the low-temperature project.

The volume of thermometric and pyrometric test work, much of which is for industry, has remained about the same as in the previous year. The Section has also been called upon to assist industry by carrying out tests and minor investigations on hygrometry, measurement and moisture content, heat transfer, and temperature measurement and control generally.

By international agreement at the Ninth International Conference of Weights and Measures, the Bureau International des Poids et Mésures during the year made certain changes in the international temperature scale, which it is one of the functions of the Section to maintain. The new scale differs from the provisional scale adopted in 1927 only in minor aspects, and the scale above 630° C. will be slightly changed. Certain changes in nomenclature, namely, the decision to reserve the term "Centigrade degree" for the thermodynamic scale and to use the term "Celsius degree" for the international scale, have been recommended. The only alteration in technique resulting from the adoption of the new scale is the replacement of the melting point of ice (0° C.) by the triple point of water (+ 0.0100° C.) as a fixed point for precise measurement.

(*a*) *Temperature Measurement and Control.*—The range of temperatures in which precise measurement is in general most important is that for which resistance thermometers are the means of interpolation between the fixed points of the international temperature scale. To increase the accuracy of measurement in this range a number of improved resistance thermometers have been constructed in the Division. Assistance has been given to other Divisions in the construction and use of resistance thermometers necessary for accurate temperature measurement.

The technique of calibrating thermocouples at the freezing point of various metals has been simplified by using the direct current galvanometer amplifier mentioned in a previous report, combined with automatic recording of the measurements. Lack of homogeneity in the electrothermal properties of the wire of rare metal thermocouples can seriously limit the accuracy of measurement of high temperatures. The effect of physical and chemical inhomogeneities in the wire is being investigated, and the measurements have been considerably simplified by the use of the galvanometer amplifier referred to above.

The Section receives many temperature measuring instruments, chiefly thermometers, for test and examination, inspects pyrometric installations, and tests furnaces and equipment used in the heat treatment of metals in industrial establishments. Many requests have been received during the year for assistance or advice in problems of temperature measurement or control.

The direct current galvanometer amplifier referred to above has been redesigned to provide for greater stability, and is proving very useful for general purposes. A device suitable as a temperature programme controller has been designed and will shortly be completed. This instrument is intended primarily for use with thermocouple temperature measuring instruments, but could be adapted for use with resistance thermometers.

(*b*) *Hygrometry and Moisture Content.*—The measurement of humidity and moisture content of materials is of considerable importance in industry and in research, and the Section has in the last few years given considerable attention to it. To meet the recurring requests for information and advice, a report on psychrometry has been prepared which includes the results of the Section's work on the effect of air speed and element size on the temperature depression of a wet element and describes various types of thermocouple psychrometers developed in the Section to mee general and special requirements of humidity measurement. Consideration is being given, in co-operation with the Division of Food Preservation and Transport to the construction of a test chamber in which a known and accurately controlled humidity can be maintained The automatic dew point hygrometer described in a previous report is proving very useful in connexion with water precipitation investigations, and the design of an instrument having a time-constant of a fraction of a second is being considered.

Further work has been done on the use of thermal measurements to determine moisture content of sand and similar materials. In this method a temperature rise is observed which is related to the product of specific heat, density, and thermal conductivity of the material; at least two of these increase significantly with moisture content. The method is at present being applied to foundry sands. Some work has also been done on the measurement of the moisture content of wool by an electrical method, in conjunction with the Fleece Analysis Laboratory of the Division of Animal Health and Production. It seems doubtful, however if the accuracy of the method is suitable for commercial requirements.

(*c*) *Heat Transfer.*—Equipment of the guarded hot plate type for the measurement of thermal conductivities of insulating materials has been designed and constructed in the Division for the Building Research Section.

An interesting application of thermal conductivity has arisen in connexion with determinations made by the Division of Radiophysics of the temperature of the surface of the moon, as indicated by measurements of the energy radiated by the moon at 1.25-centimetre wavelength. The intensity of the observed radiation depends on the moon's surface temperature, which in turn depends on the thermal conductivity of the material of the surface. Estimations of the conductivity to be expected for this material have been made in conjunction with Dr. Jaeger of the University of Tasmania. These calculations take into account the fact that the material, which is assumed to be powder or gravel of rock-like material, has a conductivity much lower than was thought, because of the absence of any appreciable atmosphere on the moon. Previously, little was known of the thermal conductivity of powders at low gaseous pressures, although they might be of considerable practical importance.

(*d*) *Precipitation.*—Laboratory investigations have been continued on physical phenomena associated with natural precipitation. Two main lines of investigation have been followed: studies of ice crystal formation, particularly that induced by the local cooling which occurs when carbon dioxide snow particles are dropped through a fog of supercooled water droplets, and studies of the growth of water droplets as they fall through a mist of much finer water droplets. These are reported in full in Chapter XXV., Section 8.

The work of the Section on precipitation is proceeding parallel with that of the Division of Radiophysics and close liaison is maintained.

(*e*) *Low-temperature Physics.*—The liquid helium generator and cryostat intended as the basic equipment for establishing a programme of low-temperature physics in the Section has not yet been brought into operation, principally because of delays in the delivery of the helium compressor for use with the cryostat.

The equipment is intended to supply facilities for maintaining any desired temperature down to 2° K. in the working space of the cryostat, and will also suitable for liquefying helium or any other gas such hydrogen, neon, or argon in quantities sufficient r experiment external to the cryostat.

Research at low temperatures requires precise tem-rature measurement by the methods of gas rmometry. The necessary apparatus is under design d the pressure measuring equipment will be suitable r use also as a helium vapour pressure thermometer. w-temperature research involves extensive use of cua to minimize heat losses. To simplify the oblem of ensuring that such equipment is vacuum ght, a mass spectrometer leak detector has been nstructed and has proved of great value.

3. Light.

The basic work of the Light Section consists of two rts: optics and photometry. The Section, however, s been responsible for some important researches in lar physics during the year.

(a) *Photometric Standards.*—Last year the inter-ational standard of candle power previously based on candescent electric lamps was replaced, by inter-ational agreement, by a standard capable of being t up in any photometric laboratory. The new unit known as the candela. It will be some time before is practicable to set up in the laboratory the equip-ent necessary to realize the candela. As lamps alibrated in terms of the new unit will in any case e an essential part of the laboratory equipment, groups f lamps which will be measured at the National hysical Laboratory, England, are being obtained to ermit the measurement of candle power, colour tem-erature, and luminous flux.

(b) *Spectrophotometry.*—The recording spectro-hotometer has been in almost continuous use during he year and has produced over 350 spectrophotometric urves. This instrument is suitable for work in which high degree of accuracy is not essential, but it is ecessary to have a more accurate instrument for ertain investigations and as a means of calibrating ther instruments. As no such instrument is available ommercially, the design of a sensitive and accurate pectrophotometer has been commenced.

(c) *Haemoglobinometry.*—The Division's service in upplying calibrated solutions of haemoglobin is roving of value to pathologists. A number of haemo-globinometers of the photoelectric type have been alibrated. Arrangements are being made with the National Physical Laboratory, England, to carry out a comparison of the haemoglobin standards being used in the two countries. This is a matter of some importance as appreciable errors have been found in the past in the standards accepted in some countries for the determination of haemoglobin in blood.

4. Solar Physics.

An officer of the Division has developed a theory of the origin of chromospheric flares which will give fresh impetus to research in this field. The theory attributes these flares to electric fields resulting from the changing magnetic field of sunspots. It has led to studies of the excitation conditions of the hydrogen constituting most of the sun's atmosphere and to the study of further problems concerning solar phenomena. This work is reported in detail in Chapter XXVI., Section 4.

5. The Physical Properties of Wool Fibres.

Work has been hampered by the difficulty of obtaining additional research staff, and consequently the study of the elastic properties of crystalline keratin, the programme for which was outlined in the last report, is not yet under way.

The addition of a chemist to the staff has enabled the physical effects of various chemical treatments to be studied.

Work being undertaken on the surface structure of the wool fibre, the frictional properties of the wool fibre, and a fibre length meter is reported in detail in Chapter XIV., Section 9.

XXIII. ELECTROTECHNOLOGY.

1. General.

The electrical research of the Organization is undertaken within its Division of Electrotechnology. It is also collaborating with the Electricity Supply Association in encouraging electrical research within the Universities through its Electrical Research Board.

The Division of Electrotechnology forms part of the National Standards Laboratory. It is responsible for the maintenance of the Commonwealth Standards of Measurement of electrical quantities other than the primary electrical standards—the volt, the ampere, and the ohm. In addition to its research on electrical measurements and standards, the Division is undertaking investigations on the properties of materials of interest in electrotechnology, e.g., dielectrics and magnetic materials.

The work of the Division during the current year is outlined in Sections 2-7 below. The activities of the Electrical Research Board form the subject of Section 8.

Division of Electrotechnology.—The Chief of the Division, Dr. D. M. Myers, accepted the post of Professor of Electrical Engineering at the University of Sydney, and took up his new duties early in March.

In April, 1949, the mathematical group of the Division was made a separate section and it is now accommodated in the Electrical Engineering Department under Professor Myers's general supervision. Its work is reported in Chapter XXVIII.

The measuring facilities of the Division have been extended during the year and all normal demands at power and audio frequencies are being satisfied. Some members of the Division have given assistance to the National Association of Testing Authorities by serving on committees dealing with the registration of laboratories for various fields of electrical testing.

The section dealing with the properties of materials has been strengthened by the addition of a number of research officers working on the mathematical, physical, and chemical aspects of dielectric materials. The main line of investigation at present is the relation between molecular structure and dielectric properties. Significant contributions have already been made by the section in this field. Apart from the fundamental importance of such work, it should lead to a clearer understanding of the molecular structures compatible with good dielectric performance, and to the possible development of high-quality dielectrics with improved mechanical properties.

2. Direct Current.

The electrometer instrument developed for the measurement of high insulation resistance has been used for investigating the nature of anomalous charge and discharge currents in dielectrics. Measurements have been made on myristone, laurone, palmitone, paraffin wax, polystyrene, and glass. The anomalous currents in polystyrene were found to be several orders of magnitude lower than in any other material investigated.

A new method of compensating a substandard instrument for temperature changes was worked out. It involves manual adjustment for each temperature, but has some advantages over the more usual methods in the number of current and voltage ranges that can be handled satisfactorily with a single instrument. A multirange instrument of this type is being built up for use as a check instrument.

Measurement of the resistance of the Division's set of standard resistors over a period of several years has revealed small departures from the expected smooth drift curve. Since these departures are consistent for coils of a given value at any time, it has been decided to investigate their cause. To permit this to be done, four standard resistors of a different make have been obtained for comparison with the Division's resistors over the next twelve months.

3. Power Frequency.

The development of circuits to control the frequency and voltage of a pair of sine wave alternators was completed. Stability over short periods of about 0.003 per cent. in frequency and 0.01 per cent. in voltage was obtained. The voltage of each alternator can be adjusted over a wide range, and the frequency can be adjusted between 20 and 60 c/s. The control equipment in its final form is now under construction.

The electrostatic voltmeter used as a transfer instrument proved sufficiently stable over fairly long periods following the modifications made earlier, and a scale reading directly in volts has been constructed to replace the linear scale used in testing the instrument.

By means of two step-up transformers and a potential divider, all of which were designed and constructed by the Division, the range of the electrostatic voltmeter was extended down to 1 volt and up to 6,600 volts. Any power frequency voltage between these limits can now be measured to an accuracy of the order of 0.01 per cent.

New coils and a new suspension were fitted to the dynamometer wattmeter used for the measurement of power. The new components, together with a modified clamping arrangement, have reduced the self-heating drift of the instrument to satisfactory limits.

A number of current transformers and current transformer testing sets have been calibrated for external organizations. The accuracy at present attainable in measurements on current transformers is adequate for all normal purposes. However, work is in hand to extend the range of measurements at heavy currents by modifications to some existing transformers and at light currents by the construction of resistors of low phase angle for use in the absolute method of calibration by means of primary and secondary resistors.

Voltage transformer testing equipment has been set up in a temporary form and extensive tests have been carried out within the present range limits of the equipment. Several three-terminal air-dielectric capacitors have been constructed for use as part of a capacitance potential divider and have given very good results. A satisfactory design of oil-filled bushing has been developed for use in a compressed-gas capacitor rated at 132 kV.

Equipment for testing insulators and insulating materials at voltages up to 100 kV. has been set up and experimental work has been commenced on a multirange voltmeter for use with this equipment.

A yoke permeammeter and a Lloyd-Fisher square, together with auxiliary control and measuring equipment, have been set up and tested. Extension pieces have been fitted to the permeammeter to allow short specimens of material of high coercive force to be tested.

4. Audio Frequency.

The Section continues to meet a steady demand for the precision measurement of capacitance and inductance and the determination of dielectric properties at low frequencies. In addition, a number of different instruments have been tested including cinema projectors, an electroencephalograph, and a chronotron. The testing of the latter, which is designed to measure small time intervals, was greatly facilitated by the completion of the counter frequency meter. The development of a self-contained electron tube which would itself count a number of cycles has been continued. A successful scale-of-five counter tube has been produced and work is proceeding on a scale-of-ten tube with a number projection system.

The installation of the frequency standard and its float-charged battery power supply was completed in January. Experience with the equipment indicated that modifications to the charging system would be necessary and these have been completed. Arrangements have been made to send time signals daily to Mt. Stromlo Observatory. There they will be compared with the Observatory's clocks and with similar time signals from the Postmaster-General's Research Laboratories, Melbourne.

To speed electronic developmental work a number of regulated power supplies, multimeters, and a vacuum-tube bridge have been constructed.

5. Radio Frequency.

The existence of fairly strong absorption lines of certain molecules in the microwave spectrum has indicated the possibility of developing standards of frequency comparable in performance with the present standards of length based on atomic spectral lines. In order to investigate this field of work, the Section has developed a system similar to that described by Hershberger and Norton (*R.C.A. Review*, March, 1948) in which the frequency of a microwave oscillator is locked to an ammonia absorption line (23,870 Mc/s) by using an appropriate servo-mechanism. Frequency stability of the order of 1 part in 10^6 is reasonably easy to attain, but considerable development would be required to produce a frequency stability comparable with that of the best quartz-crystal oscillators.

Equipment has also been designed and is at present being constructed for more fundamental studies in the field of microwave spectroscopy.

A general-purpose thermistor bridge for the measurement of radio-frequency powers of the order of a few hundred microwatts has been developed. Its immediate application is the precise measurement of the power output of standard signal generators in the frequency range 30-300 Mc/s. In order to improve the absolute accuracy of power measurement at these frequencies, an indirect determination of the percentage of power lost in the thermistor matching networks has been made by means of a series of impedance measurements.

6. Properties of Materials.

(*a*) *Dielectric Properties of Organic Compounds.*—In order to study the relationship between molecular structure and dielectric properties, a wide range of polar and non-polar organic compounds of varying chain-length have been prepared in a pure state. The dielectric properties of pure polar compounds and of various concentrations of polar compounds in non-polar solvents have been measured, mainly in the frequency range 50 kc/s to 50 Mc/s.

Following the programme of the previous year, in which long-chain esters were used as the polar compounds and various hydrocarbons as the non-polar solvents, the work has been extended to long-chain ketones and alcohols. From loss angle measurements over the above frequency range, the relationship between relaxation time and ketone chain-length has been determined for solutions where the solvent chain-length is greater than that of the ketone. The effect of introducing ketone solutes into shorter chain-length ydrocarbons has also been investigated and the results ompared with previously established X-ray data on ystems of this type.

As the concentration of polar solute is increased, ipolar interaction also increases and its effect on ielectric properties has been studied by measuring both ster and ketone systems of varying concentration and inally in the pure state. The results for the system -hexacosane-laurone have been interpreted in conjunction with the solid-liquid phase diagram.

A preliminary investigation of secondary alcohols in he pure state has indicated the presence of strong hort-range forces giving rise to unexpectedly high ielectric absorption at audio and radio frequencies. The results have been described in a letter to *Nature*. ow-frequency measurements indicate that interaction f a somewhat different nature may also occur in ure ketones and esters.

(*b*) *Theoretical Investigations.*—During the year, heoretical investigations were begun on the behaviour f dielectric materials under applied alternating urrent and direct current fields, both along general lines and with specific reference to the substances experimentally examined in this Section.

It was found that in ionic crystals with mobile imperfections, the frequency of maximum dielectric absorption depends not only on the probability of an elementary displacement, but also on the possible range of such displacements, thus showing that the usual procedure of interpreting absorption curves in terms of molecular processes is inadequate in such cases. Similar considerations apply to dipolar chains with strong short-range interaction, as found above in solid secondary alcohols, and presumably in ice.

Investigations were carried out in collaboration with the Department of Chemistry of the University of Sydney concerning the static dielectric constant and the Kerr effect of substances whose molecular shapes differ appreciably from spheres, with particular reference to sulphur dioxide. A joint paper on these researches is in course of preparation.

The thermal and dielectric properties of a number of models were investigated. The techniques and results are interesting from a mathematical point of view and capable of further extension. To date, they have been applied to the static dielectric constant of alcohols and long-chain polymers.

(*c*) *Dielectric Measurements.*—Dielectric investigations can with advantage make use of accurate measuring techniques over the widest attainable range of frequencies, and the development of equipment is planned to this end.

The electrometer instrument developed by the Direct Current Section has proved very useful for the measurement of high values of insulation resistance at direct current, and developments are under way to increase the sensitivity of this equipment. From 50 c/s to 100 kc/s, a suitable bridge technique has been developed. A Q-meter technique is at present used to cover the range 50 kc/s to 50 Mc/s, but it is not sufficiently accurate for the more precise work on high-quality dielectric materials.

Above 50 Mc/s, the problem of providing a continuous frequency coverage is formidable. Measuring facilities are now available, however, at fixed frequencies of 100, 150, 300, 1,000, 3,000, and 9,000 Mc/s, and equipment for 25,000 Mc/s is in the course of development.

7. Applied Electronics.

The flight trials, held in collaboration with the Division of Radiophysics, of the mechanism for plotting the radar ranges of a Shoran-equipped aircraft from two ground stations have been concluded. With the aid of this mechanism, the pilot was able during the trials to fly the aircraft along a series of straight and parallel courses so that vertical aerial photographs could be taken with the desired amount of side overlap. Signals for triggering the camera at the correct interval were also obtained from the plotter. Thus, the equipment should permit a series of overlapping aerial photographs to be taken with the minimum flying time and wastage of film.

8. Electrical Research Board.

The general objectives of the Board were outlined in the previous Annual Report (Chapter XXII., Section 8).

The Board has continued to receive financial support from member organizations of the Electricity Supply Association of Australia, and has been able to grant financial assistance to the electrical engineering departments of several universities. The earlier applications for grants, with the possible exception of the work being undertaken by the University of Tasmania, provided for no continuity of work, but those of the present year show signs of developing into a co-ordinated programme which might continue actively in the universities concerned.

As anticipated, the shortage of suitable graduates and the heavy requirements of industry for trained engineers have restricted the activities of the Board. During the past year work on power system stability has been continued at the University of Melbourne, and work on transient phenomena at the University of Tasmania. Support has been given to the Electrical Engineering Department of the University of Adelaide to permit work on simulating networks for testing transients on power networks to be continued. The work on telemetering and supervisory control systems being carried out at the University of Sydney has been completed.

XXIV. RADIOPHYSICS.

1. General.

The Division of Radiophysics was established during the war to initiate in Australia research on and development of radar equipment for the Services. With the return of peace-time conditions the Division's efforts were transferred to the prosecution of fundamental researches on radio and radar.

The Organization has also continued radio research undertaken in collaboration with the Postmaster-General's Department and the Universities of Sydney, Queensland, Tasmania, Adelaide, and Western Australia, under the direction of its Radio Research Board.

Division of Radiophysics.—The main activities upon which the Division of Radiophysics has concentrated during the past year have been, briefly:—

- (i) Fundamental studies of the radio-frequency radiation from the sun and the galaxy;
- (ii) The application of radar techniques to the study of natural and artificial rain formation;
- (iii) Electronic methods of solving mathematical problems;
- (iv) Radio and radar methods of navigation and surveying.

The work, therefore, has been a continuation and extension of that described in last year's report. Interesting advances have been made in each of the above fields, and in several cases the researches have been brought to the point where they can be applied to different problems in the community.

The work of the Division is outlined in Sections 2–11 below.

Radio Research Board.—The aim of the Radio Research Board since its inception in 1928 has been to carry out fundamental investigations in radio propagation and to assist and encourage such research in the universities.

Full-time officers of the Board are located in Canberra at the Commonwealth Observatory and in Sydney in the Electrical Engineering Department of the University. They work as one team in a combined experimental and theoretical attack on fundamental problems. Further groups of part-time officers work in the Universities of Queensland and Western Australia, while the Board also assists work in the Universities of Tasmania and Adelaide and in the New England University College at Armidale, New South Wales.

The Board co-operated with the Australian National Antarctic Research Expedition by training an officer and supplying equipment for examining the ionosphere above Macquarie Island.

The Board arranged a conference held in Sydney from 30th May to 3rd June, of all Australian scientists working on ionospheric problems. This resulted in important exchanges of results and ideas and in the formulation of co-ordinated plans for future research.

The work of the Board is outlined in Sections 12–15 below.

2. Radio Astronomy.

The Division of Radiophysics has been responsible for major advances in a new science of radio astronomy and has made important contributions in the fields of solar noise, stellar radiation, and galactic noise. This work is described in detail in Chapter XXVI., Sections 2, 5, and 6.

3. Lunar Observations.

The series of observations on radio echoes from the Moon, on a wavelength of 15 metres, which were commenced last year have been concluded. The outstanding feature of these experiments is that a controllable signal which passes through the ionosphere and returns by the same path provides a means of investigating conditions in the highest regions of the Earth's atmosphere. The results of these observations are now being analysed and will indicate whether the erection of a high-power transmitter and aerial system for further work on these lines is warranted.

4. Vacuum Physics.

The Vacuum Laboratory has been maintained throughout the year and its facilities made available to other Divisions of the Commonwealth Scientific and Industrial Research Organization and to the Electrical Engineering and Physics Departments of the University of Sydney. The Division's experimental work in this field has been restricted because of the absence of officers abroad. However, two new lines of work have recently been commenced.

(*a*) *Growing Waves in Electron Streams.*—Arising from laboratory experiments in America and theoretical work in Australia it has been found that, under suitable conditions, a radio wave can grow or be amplified by interaction with an electron beam. On the practical side, the phenomenon may lead to the development of entirely new techniques for amplifying and generating radio waves, while on the theoretical side it may go far towards explaining the occurrence of non-thermal radiation from the sun and the stars. Due to the importance of this subject, a programme has commenced for the study of this phenomenon in the laboratory.

(*b*) *Transistors.*—Engineers of the Bell Telephone Laboratory in America recently described methods by which germanium and silicon crystals could be made to operate as amplifiers. The discovery is of considerable practical importance and may lead to simple replacements for thermionic valves. A study of the amplifying properties of these materials is, therefore, being carried out, in conjunction with officers of the Department of Electrical Engineering, University of Sydney.

5. Mathematical Physics.

The main function of the Mathematical Physics Group is to undertake mathematical work directly concerned with the current programme of the Division. This is at present chiefly in the fields of tropospheric and ionospheric propagation, the antenna theory of long waves, and the coalescence of raindrops. In carrying out this work it has been necessary to make considerable use of mechanical and electrical computation methods. This latter subject is very much in the formulative stages and it has been found convenient to leave the bulk of the mathematical work of the Division in abeyance until computing methods have been developed. Progress has been made in the adaptation of automatic punched card equipment for these purposes and in the design of a special electronic calculating machine intended to solve problems of interest to the Division. Further details are given in Chapter XXVIII., Section 4.

6. Rain Physics.

The rain physics programme is divided into two main parts: the investigation of the physics of the different methods of formation of natural rain, and the study of the artificial production of rainfall by the dry-ice process. This work is described in detail in Chapter XXV., Sections 6 and 7.

7. Radar Aids to Civil Aviation.

The past year has seen the virtual completion of the development of the particular radar aids to civil aviation upon which the Division has been engaged since the end of the war. It is, therefore, becoming possible to divert effort towards more fundamental investigations arising out of this work.

(*a*) *Distance Measuring Equipment.*—Distance Measuring Equipment ("D.M.E.") is a radar set designed for installation in an aircraft to provide the pilot with a direct indication in miles of his distance from beacons at known points on the ground.

Largely as a result of the development and successful demonstration of this device by this Division, the Department of Civil Aviation has placed orders to the extent of £600,000 with Australian manufacturers for the ground-based components of "D.M.E.", the beacons. These beacons will be placed at terminal airports and at regular intervals along all air routes. The manufacture of the airborne units for "D.M.E." will be the responsibility of the airline companies. The Division is assisting the Department and the airline companies to gain operating experience of this new navigational aid and arranging for six sets of aircraft equipment to be manufactured for use before production sets become available.

At the request of the Royal Air Force two sets of Distance Measuring Equipment have recently been sent to Great Britain. An officer of the Division accompanied them to supervise their installation and to be present at certain of the trials, which will be carried out in conjunction with the Division's Multiple Track Range equipment. The latter has already been successfully used for some years in other experimental navigational procedures being tried out by the Royal Air Force.

(*b*) *The Multiple Track Range.*—This is a radar- pe guidance system which provides "tracks" radiat- g from an airport, by means of which an aircraft ilot is easily able to guide his aircraft along any lected one of these tracks. Sixty or more such tracks n be provided.

This device was first conceived in 1945 and produced a usable form in 1946. Various improvements have een incorporated and six sets of the latest design have een constructed. These are being made available to e Department of Civil Aviation and the operating irline companies so that further tests to determine the uitability of the system for civil airline use in Aus- ralia may be carried out.

(*c*) *Airways Control Radar.*—Airways Control adar is designed to allow an air traffic control officer o fix the positions of aircraft within 100 miles of his irport. An experimental installation, making use of modified high-power radar set developed for the oyal Australian Air Force, has been completed and anded over to the Department of Civil Aviation. It s undergoing operational trials to determine whether r not such a device is a desirable adjunct in air traffic ontrol procedures.

(*d*) *Air Traffic Control.*—During the development f navigational devices for use in civil flying it became lear that some of the characteristics of air traffic itself, and therefore the problems to be met in its control, were insufficiently understood. Several lines of work were, therefore, taken up in an attempt to obtain a better appreciation of these problems. These proceeded in four main directions.

- (i) Theoretical studies of the properties of a flow of traffic arriving at an airport, at random, and when subject to specified controls;
- (ii) Analysis of the characteristics of the traffic pattern and landing delays experienced at actual airports under existing methods of control;
- (iii) Experimental investigation of typical problems on a model basis, by simulation methods;
- (iv) Full-scale tests of several possible procedures.

All this work has been brought to completion during the current year and either published or prepared for publication.

(i) *Orbiting Approach.*—The Division's Distance Measuring Equipment and Multiple Track Range were used for full-scale flight tests to determine the accuracy with which a particular type of approach manœuvre known as "orbiting" could be carried out in the vicinity of an airport. With the co-operation of the airline companies and the Department of Civil Aviation a total of 98 separate approaches was made, in which more than 30 pilots participated.

The tests demonstrated clearly that considerable advantages in all phases of an approach may be obtained if an aircraft pilot is provided with complete instrument guidance.

(ii) *Simulation Experiments.*—Examination of the characteristics of the flow of air traffic to existing airports indicated that individual aspects of this problem deserved detailed study. It was desirable that experiments be carried out in which a number of alternative methods of control could be used. Such tests are, of course, impracticable on a full scale at an active airport and equipment was therefore constructed to allow them to be made on a model basis, by simulation methods.

These simulation tests were carried out on specially constructed equipment over a period of six months. A number of control methods was studied under conditions which allowed the results to be treated by statistical methods. This work is likely to throw valuable light on the limitations of currently-used methods of traffic control, and on the modifications which are likely to lead to improved performance, e.g. in the reduction of delays experienced by aircraft in landing.

At the request of the Department of Civil Aviation the simulation machine was transferred to that Department at the conclusion of the above tests. It is to be used for the training of traffic controllers, and for further studies in the problems associated with the control of air traffic.

(*e*) *Microwave Direction Finding.*—A fundamental investigation has been initiated into the possibilities of the use of wavelengths in the microwave region—1 to 10 centimetres—for direction-finding purposes.

It has been normal practice for many years for aircraft to carry radio direction-finding equipment as an aid to navigation. By this means a pilot can readily obtain his bearing from selected stations, one at a time, within range. The use of microwaves will, however, make it possible to present to the pilot a more comprehensive and accurate picture than is at present available. For example, all ground beacons within range may be displayed simultaneously so that a pilot is able to gain a better appreciation of the position of his aircraft and hence navigate more easily in difficult areas such as the approaches to an airport.

8. RADAR AIDS TO SURVEY.

(*a*) *Measurement of Long Baselines.*—The experimental programme, which was begun in 1947 at the request of the National Mapping Council, to investigate the accuracy with which long baselines (200 to 500 miles) could be measured by radar means has been concluded. These tests were carried out with "Shoran" equipment which had been slightly modified for the purpose. It was clearly understood that this radar set was not necessarily an ideal set for the purpose, but it was expected that the experiments would give all the technical and operational information required by the National Mapping Council to enable it to decide whether or not radar should be used for geodetic surveying in Australia.

In an extensive series of flight tests completed during the year all dimensions of the quadrilateral embracing Sydney, Canberra, Condobolin, and Tamworth were measured by radar. As these distances were all known from first-order ground survey measurements, a unique opportunity was presented to assess the accuracy with which distances of this order (200 miles) could be measured by radar. The "Shoran" equipment, as used, gave an accuracy of 7 parts in 100,000 but with simple modifications could reasonably be expected to achieve an accuracy of 2 parts in 100,000.

Further developments in the use of radar for survey purposes now depend on its actual use by surveyors in order that the technique of making measurements under field conditions, and of the proper reduction of the results, may be thoroughly understood.

(*b*) *Use in Aerial Photography.*—The use of "Shoran" radar equipment as an aid during the taking of survey photographs from the air has also been investigated. A special attachment for the "Shoran" equipment, known as a straight line computer, was developed in conjunction with the Division of Electrotechnology, to provide instrument guidance to an aircraft pilot so that he could fly accurately along a series of parallel tracks covering the area to be surveyed. This instrument automatically operates the survey camera at the correct points. Flight tests have been carried out with it which show that its average error is 150 feet, well within the limits required for the purposes for which it was designed.

9. MEASUREMENTS AND STANDARDS.

The Division's Test Room has, as in the past, been responsible for the maintenance and calibration of the large range of radio and electrical test and measuring equipment in use within the Laboratory.

This Section has, in addition, carried out the following investigations:—

(i) The design and development of a special electronic valve whose output is sensitive to pressure. This is known as a pressure-sensitive transducer and offers a means of measuring pressure changes electronically. It was developed originally for use in aircraft to provide an electrical output proportional to height, but has other useful applications.

(ii) The use of certain crystal materials, e.g. germanium and silicon, as oscillators and amplifiers.

The following special equipment has also been constructed for use in Laboratory investigations:—

(i) A special receiver for checking the performance of "noise" generators;
(ii) Two noise generators for use at 30 and 200 Mc/s respectively;
(iii) Five wavemeters, covering a range from 50 to 500 Mc/s;
(iv) A special receiver tuning from 60 to 300 Mc/s for use in conjunction with impedance measuring equipment.

10. RADIO CONTROL AND TELEMETERING.

In our previous report it was indicated that work on the development of radio control techniques suitable for fitting to model aircraft had been initiated, in co-operation with the Aeronautical Research Laboratories.

This Division is primarily interested in radio-controlled aircraft as a further vehicle for the carrying aloft of meteorological instruments. A number of successful flights have been carried out with radio-controlled models capable of carrying radio telemetering equipment, the purpose of which is to transmit back to the ground station readings of meteorological instruments installed in the model.

11. HIGH ALTITUDE WIND FINDING.

A programme of upper air soundings has been commenced using radar methods. This work is reported in detail in Chapter XXV., Section 9.

12. ANOMALOUS VARIATIONS IN THE PRINCIPAL (F_2) REGION OF THE IONOSPHERE.

The F_2 region of the ionosphere is responsible for nearly all long-range radio communication. Great difficulty is experienced in predicting its characteristics at given seasons and times of the day and in given locations. Already millions of pounds have been spent in the establishment of ionospheric observatories in inaccessible parts of the globe in an effort to bring order into the erratic variations of this vital radio reflecting region, which exists about 200 miles above the Earth's surface. As a result of the Board's post-war work there is good reason to believe that the principal cause of the anomalous behaviour of this region has been found. It has been established that giant tidal air movements occur in this region. Under the influence of these tides, which are produced by both the Sun and the Moon, the reflecting region rises and falls by as much as 50 miles. At the same time the layer is distorted, and its ability to reflect short radio waves is much modified. Now that the cause of these anomalies appears to have been found, there is good reason to believe that it will eventually be possible greatly to reduce the expenditure of effort and money on the maintenance of observatories in remote areas and in the provision of *ad hoc* predictions to communication services.

This work has naturally aroused great interest abroad. At the recent Stockholm Assembly of the International Union of Scientific Radio (U.R.S.I.) it was decided to prepare a special report on "Tides in the Ionosphere", to be published in English and French. An international committee has been set up to prepare this report under the Chairmanship of the Board's Chief Scientific Officer.

13. TRAVELLING IONOSPHERIC DISTURBANCES.

Since the war the Board's officers, by applying techniques developed for radar purposes during the war, have established a system for recording horizontal movements in the ionosphere. Very little information of this type was previously available, but this investigation has shown the frequent occurrence of large disturbances which travel horizontally in the ionosphere at speeds of several hundreds of miles per hour. They extend vertically at least through the region between 200 and 300 miles above the Earth and, in particular cases, have been shown to travel at least the 550 miles from Canberra to Brisbane. The system thus provides a new tool for the study of the upper atmosphere and further studies of the origin, extent, movement, and characteristics of the disturbances are likely to yield much valuable information on the conditions and changes at these great heights and their relation to atmospheric and magnetic changes in the lower atmosphere and at the Earth's surface.

To explain the characteristics of these disturbances it has been necessary to develop anew the theory of travelling presure waves in the atmosphere. This has led to some quite unexpected conclusions. For example, it has been found that the modes of propagation of these oscillations (of periods less than an hour) in the lower atmosphere have not hitherto been properly understood. These oscillations include a variety of phenomena such as the cells of "bumpiness" affecting aircraft, certain types of billow clouds, and regular oscillations of the barometer. It has been found that the theoretical work necessary to explain the ionospheric disturbances satisfactorily accounts for these well-known phenomena in the lower atmosphere, which are quite unconnected with radio problems. Thus still another example appears of fundamental research in one field yielding results of importance in another apparently unrelated field.

This work is being actively pursued both experimentally and theoretically, not only for its own sake, but because it may provide a clue to the relations between weather circulations in the upper and lower atmosphere, a subject of obvious importance about which almost no information exists. A wide network of observing stations is being set up at all the centres participating in the Board's work.

14. RADIO RADIATIONS FROM THE SUN.

Following the experimental discovery by the Board's officers that the radio radiation from sunspots was circularly polarized, attention was devoted to a theoretical study of the origins of solar radio radiations. This work is described in detail in Chapter XXVI., Section 3.

15. OTHER INVESTIGATIONS OF THE RADIO RESEARCH BOARD.

Other work on hand includes the investigation of the small regular variations of the compass needle which occur daily, and the larger irregular variations ich occur at times of solar activity. These variations are known to be produced by electric currents in e ionosphere, but little is known about the precise echanism which causes these currents, nor have the yers of the ionosphere in which they flow been entified. Considerable progress is being made on th these points.

It is known that the regular daily variations of e compass needle are exceptionally large in certain rts of the Earth near the magnetic equators. This oblem is being examined theoretically in collaboraon with an officer of Amalgamated Wireless Ausalasia (Ltd.). In addition, at the instigation of e Board, the Bureau of Mineral Resources (Department of Supply and Shipping) is planning an expedion to study these variations in certain islands of the acific where there is reason to believe they may be ceptionally large.

Other investigations in hand include (at Brisbane) e study of the sporadically occurring E region of e ionosphere, which is occasionally responsible for ceptionally long-range radio communication on high equencies, and (at Hobart) the study of unusual ultiple echoes from the ionosphere.

XXV. METEOROLOGICAL PHYSICS.

1. General.

Although for many years systematic meteorologists ave studied the day-to-day changes in Australian eather, studies of the fundamental phenomena underying these changes have rarely been undertaken. Because of the importance of weather to Australia, he Organization has embarked on intensive studies of he physics of the atmosphere, as only through a nowledge of the basic physical phenomena can radical ew developments emerge.

Work on dynamical meteorology, on general circulaion and heat balance and on micrometeorology is being carried out within the Section of Meteorological Physics with laboratories at Highett, Victoria (*see* Sections 2-5 below).

Arising out of studies on the propagation of very short radio waves, the Division of Radiophysics has been working on the physics of rain formation (*see* Sections 6 and 7 below) and the Division of Physics has undertaken work on certain aspects of this project (*see* Section 8 below).

The Division of Radiophysics has also commenced a programme of upper air soundings which is described in Section 9 of this Chapter.

Statistical work on rainfall in South Australia being done by the Section of Mathematical Statistics is described in Section 10 below.

Section of Meteorological Physics.—The work of this Section during the past year has been largely preparation. At the beginning of the period the scientific staff numbered four, of whom three had just assumed duty, and the plans for the work of the Section had been broadly determined. Early in the year the Section occupied its first accommodation at Highett, although the laboratory and workshop did not come into use until the year was well advanced. Some equipment is still awaited. Progress has been made in the design and construction of new instruments for the specific fundamental work of the Section, and it is expected that the field work will be started during the coming year.

During the year the Officer-in-Charge attended the Seventh Pacific Science Congress held in New Zealand and was appointed chairman of the sessions on research needs and techniques and a member of the standing committee on Pacific meteorological research.

Monthly joint symposia on meteorology are now held with the Commonwealth Meteorological Branch and the Meteorological Department of Melbourne University.

Advice has been given on miscellaneous meteorological matters not immediately related to the work of the Section to other Divisions and Sections of C.S.I.R.O., and also to the Antarctic Division of the Department of External Affairs, the Radio Research Board, the Sydney Metropolitan Water, Sewerage, and Drainage Board, and the Ministry of Post-war Reconstruction.

2. Dynamical Meteorology.

Theoretical and practical studies of the movement and behaviour of pressure systems have been continued. The work of the Section in this field provides a necessary fundamental background and supplement to the provision of weather forecasts, which is the task of the Commonwealth Meteorological Service. The research problems are subtle and difficult, and call for the development of new approaches and exploratory methods as an adjunct to the routine methods in current use. One such approach under development is the consideration of the energy exchanges within and between depressions and anticyclones which are regarded as discrete vortices, and this has led to further progress in understanding the movement of these systems and in providing criteria for the intensity and stability of anticyclones.

Kinematic and dynamic studies of the wind structure in depressions and anticyclones have led to the conclusion that the motion of these systems is greatly affected by the horizontal wind distribution and dominated by the thermal distribution over the regions of strongest winds and not, as previously supposed, over the centre. The energy method has shown that the most stable anticyclone is one in which the wind is constant with height and varies in proportion to distance from the centre. The nearness with which this ideal state is approached may form one criterion for the persistence of the anticyclone type of weather.

Climatic wind data are being examined in an attempt to define their usefulness for dynamic studies.

3. General Circulation and Heat Balance.

A current meteorological trend in all countries is to give increased attention to problems of the general circulation and heat balance on the global scale. In our last report mention was made of the development of a new tool by which these problems can be attacked. The best results can be achieved only by prolonged international collaboration. During the past year the preliminary results obtained were presented to the International Union of Geodesy and Geophysics, and they have stimulated the initiation of similar studies in Scandinavia, Britain, and France. Parallel work is on hand in the United States. The work, which is continuing, involves the computation and global study of the large-scale transports of heat and water vapour between the various latitudes, and of the stress which the air circulation of one latitude exerts on its neighbours.

Meteorologists all over the world regard the Southern Hemisphere as a better natural working laboratory than the Northern for general circulation studies, and any advance made is of as much world-wide as local or regional interest. The limitation on possible progress in problems of general circulation and heat balance as well as in dynamical meteorology lies in the number of stations which can be maintained making regular wind and temperature soundings of the upper air.

4. Micrometeorology.

A study of the fine structure of the layers of air near the ground is of fundamental importance to meteorology itself, besides having many potential applications in agriculture, soil and water conservation, ground conditions for traffic, and so on. The preparatory work during the past year has been concerned with the design and development of special instruments and techniques which will be required for this work. At or nearing completion are pioneer models for the determination of vertical heat transfer by turbulence in the air, the conduction of heat into the ground, and for exploring in sufficient detail the microstructure of temperature and motion in these layers.

Arrangements have been made for the establishment of a field experimental and observing site for this work at Edithvale, Victoria. The erection of a hut-laboratory, instrument tower, and other facilities on the site are now in hand.

The work requires also a knowledge of radiation exchanges. Research has led to the construction of a chart by which the exchanges of heat, through adsorption and emission of long-wave radiation by water vapour and CO_2 in the lowest few hundred feet of atmosphere, can be more accurately determined than has hitherto been possible.

Work has been started on the comparison of the evaporation, over short periods, from a free water and natural grass surface. A paper on the meteorological aspects of evaporation from natural surfaces has been prepared for the British Commonwealth Specialist Conference on Agriculture.

5. Frost Prevention.

The economic importance of protecting fruit from frost danger and the experimental fan methods devised to this end were described in the last annual report (Chapter VII.). The Section of Meteorological Physics has now assumed responsibility for the meteorological and measurement problems involved in this work. The difficulties of making sensitive temperature-measuring equipment resistant to long exposures in the field have been overcome and a layout of suitably treated thermistors, together with auxiliary equipment, now installed at Griffith, should facilitate and speed the progress of current investigations. (*See* Chapter IV., Section 3 (*c*).)

6. Natural Rain Formation.

To complete our understanding of the processes of rain formation, a study is being made of the many mechanisms which occur in nature. It has often been pointed out that the ability of radar sets to detect the presence of snow and ice or water droplets in cloud provides a powerful tool for carrying out such investigations.

It has been found in south-east Australia that raindrops begin their life as snow or ice particles, as postulated by Bergeron, on perhaps half the occasions. For the other half of the time rain appears to form without ice being present. Owing to the great scientific and practical importance of the fact that rain can fall from clouds that do not reach the freezing level, an intensive study is being made of these occasions and it is hoped shortly to have an understanding of the mechanism. Measurements are being made by radar observation of the raindrops within these clouds. These are supplemented by direct observation of the size of raindrops at different levels above the ground, made by means of a balloon-borne microphone which transmits back to the ground, by radio, a signal proportional to the momentum of the drops. Experiments are also made in which drops of a given size are introduced at known positions in particular clouds and careful observations made of their subsequent history.

7. Artificial Rain-making.

Experiments on the artificial stimulation of rainfall by the dry-ice process have continued. The results obtained are in agreement with the hypothesis that artificial raindrops have their origin in ice nuclei which were produced by the refrigerating action of the dry ice.

A powerful experimental method of investigating the phenomenon has been developed using a downward-looking radar set in an aircraft which remains above the seeded cloud during the whole of the experiment. Echoes are received from the snow, ice and raindrops produced in the cloud, estimates can be made of their size, and their growth can be traced as they descend through the cloud. As a result of this work, a reasonable prediction can be made of the effect of dry ice on any given cloud, of the time likely to elapse before rain appears from the base, and of the probability of its reaching the ground.

8. Precipitation.

Laboratory investigations have been continued on physical phenomena associated with natural precipitation.

The first investigation has been concerned primarily with determining the number and types of ice crystals formed under various conditions for a given loss of dry ice. An ancillary investigation on the rate of sublimation of carbon dioxide snow from a spherical surface exposed to air at various air speeds and temperatures has been completed and the experimental results on the numbers of ice crystals are now being analysed. Measurements of the highest temperature of a supercooled fog at which ice crystals, if present, will continue to grow has shown this to be —0.7° C.

The investigations on droplet growth are for the purpose of determining experimentally the probability of capture by a falling droplet of the fine mist droplets through which it falls. Capture cross-sections have been calculated for this problem on aerodynamic considerations by other workers, but do not seem to have been determined experimentally. A knowledge of capture cross-sections is of basic importance in theories of rain formation and raindrop growth.

9. High-altitude Wind Finding.

A knowledge of the structure of the winds at heights of 30,000 feet and above is becoming increasingly important in view of the operational ceilings likely to be in common use with jet-engined aircraft. Very few data exist at present on the winds prevailing in the region 30,000 to 100,000 feet above the earth's surface.

Radar methods are applicable to the determination of winds at high altitudes. A programme of upper air soundings has, therefore, been commenced, in which special reflecting balloons are released and their tracks followed and plotted by means of a high-power radar set.

10. Statistical Examination of Rainfall in South Australia.

The Section of Mathematical Statistics has made steady progress with its work on rainfall in South Australia. The primary analysis for determining the expectation of monthly rainfall in South Australia is complete, and the results are now being illustrated graphically on a series of maps. The work is being extended to establish the relationship between variability of rainfall within zones of equal mean rainfall, and plant ecology, and to assess the probabilities of drought of varying intensity and duration.

XXVI. EXTRATERRESTRIAL PHYSICS.

1. General.

Until recently our knowledge of the universe was derived almost entirely from the use of telescopes and from the visual and optical methods of observing which have been developed by astronomers. A new branch of science, called radio astronomy, has arisen, however, in which radio instruments are utilized for the study of astronomical objects, and it is now possible to obtain much information about the Sun and stars from the radio waves which they emit. In most cases these radio waves are emitted spontaneously either as thermal radiation—which is analogous to the light given out from incandescent bodies—or as a consequence of electrical disturbances, in a manner similar to the production of atmospherics by lightning flashes. Radio waves are generated and propagated in a different manner from light waves so that they provide new information which is often not obtainable in any other way. Radio astronomy has already made important contributions to our knowledge and, like any fundamental branch of science, is likely to lead to practical applications which could not otherwise have been foreseen. For example, attempts to explain how certain types of radio waves arise in the Sun are already leading to new techniques for the generation and amplification of radio waves.

Work in this field has formed a major part of the programme of the Division of Radiophysics and is described in Sections 2, 5, and 6 below. It is closely allied to work on solar physics being undertaken by the Radio Research Board (Section 3 below) and by the Division of Physics (Section 4 below).

2. Solar Radiation—Work in Division of Radiophysics.

Last year's Annual Report (Chapter XVI.) described how two major components of radio noise from the Sun could be recognized—a thermal component due to radiation from the very hot gases of which its outer atmosphere is composed, and non-thermal components due to disturbances in the solar atmosphere.

(*a*) *The Thermal Component.*—The thermal component has been carefully observed over a wavelength range from 1 centimetre to 4 metres and its properties are now fairly well understood. The theory of its emission has also been studied and this has led to a determination of the temperature and electron distribution over a substantial range of heights in the solar atmosphere.

Measurements of the thermal component can be used to calculate the general magnetic field existing on the Sun—a matter of considerable scientific interest. Observations made during the eclipse of the Sun visible in Australia on 1st November, 1948, indicated that the strength of this field must be less than the value previously assumed from optical evidence.

It is known that the total heat radiated from the Sun varies very little through the sunspot cycle. It is probable, however, that substantial changes will occur in the radio spectrum over the sunspot cycle, and to check this point measurements are being made at wavelengths of 3, 10, 25, 50, and 150 centimetres.

(*b*) *Non-thermal Components.*—In last year's report it was indicated that in addition to thermal radiation there were two forms of non-thermal radiation from the Sun which were named respectively "enhanced radiation" and "bursts". Further work during the past year has led to a clear distinction being drawn between them. Enhanced radiation can exist for several days or hours at a time and is associated with sunspot activity. In general, it is characterized by showing either left- or right-handed circular polarization. Bursts, on the other hand, are not necessarily associated with sunspots. They last only for seconds or minutes at a time and are not circularly polarized.

Evidence has been obtained that these bursts originate as short-lived disturbances or solar explosions some hundreds of thousands of kilometres above the Sun's surface. They give rise to pulses of radiation which often reach the Earth by two routes: one by the direct path and the other after reflection at a lower level in the solar atmosphere. The second pulse arrives at the Earth some seconds later because it has travelled a greater distance. Phenomena such as these provide another means of studying the solar atmosphere.

Further experiments are in progress on the non-thermal components, one of which is an attempt to locate precisely the place of origin of solar bursts, using an interferometer technique. In another experiment the spectrum of bursts from the Sun is observed continuously over a wavelength range from 2 to 4 metres by means of a receiver which sweeps over this wavelength range in about 1/10th second.

(*c*) *The Solar Eclipse of* 1st *November,* 1948.—Advantage was taken of the solar eclipse visible in eastern Australia in November, 1948, to determine the location of active areas on the Sun on that day. Observations were made on a wavelength of 50 centimetres at Sydney, Melbourne, and Strahan (Tasmania), while observations on 3 and 10 centimetres were also made in Sydney.

Records of solar noise made at each site showed sudden decreases in intensity as highly emitting areas on the Sun were covered by the Moon in its passage between the Sun and the Earth. By careful observation of the exact time at which emitting areas were eclipsed at the three sites it was possible to locate the position of the emitting regions relative to the Sun's disc. Most of them corresponded to the position of visible spots or to sunspot groups which had been present 27 days previously. One area, however, was found to be about 100,000 kilometres above the edge of the Sun's disc, near a prominence which occurred at that time.

3. Solar Radiation—Work of Radio Research Board.

Following the experimental discovery by the Board's officers that the radio radiation from sunspots was circularly polarized, attention was devoted to a theoretical study of the origins of solar radio radiations. It was found that most of the radiation received on metre wavelengths must come from the solar corona. Since the corona is very hot (about 1,000,000 degrees Centigrade) its thermal radiation should be detectable by radio means. This prediction was almost immediately verified experimentally by officers of the Division of Radiophysics. The theory of this radiation has been fully worked out over a wide range of wavelengths, and appears to be confirmed by subsequent observations made in the Division of Radiophysics and laboratories abroad. It was also predicted that the Sun should appear as a bright halo, with a dark centre when viewed at radio wavelengths of the order of centimetres, and this prediction too has been confirmed. It is now generally agreed by workers both in Australia and abroad that the theory developed by the Board's officers gives a satisfactory account of all thermal radiation from the Sun at radio wavelengths.

International recognition of the Radio Research Board's work in this field (as well as that of the Division of Radiophysics and the Commonwealth Observatory) was conferred by the election of the Board's Chief Scientific Officer as President of the Commission of Extraterrestrial Radio of the International Union of Scientific Radio. The latter officer, in conjunction with the Commonwealth Astronomer, has secured international co-operation in a scheme for joint publication by all laboratories or observatories throughout the world making regular radio observations of the Sun. Observations and measurements from these laboratories are now forwarded to a central bureau in the Commonwealth Observatory at Canberra. After editing at this centre, they are sent for publication in the *Quarterly Bulletin of Solar Activity* issued from Zurich.

4. Solar Radiation—Work of the Division of Physics.

The Sun, which is the motive power of all life on the Earth and of all meteorological phenomena, has a comparatively constant energy output, but its surface and its atmosphere are subject to violent localized disturbances which produce transient but nevertheless significant effects on the Earth. In the neighbourhood of sunspots, for example, chromospheric flares occur which emit radiation at a rate per unit area as much as 100 times greater than normal. These storms cause both cessation of short-wave radio transmission and measurable changes in the Earth's magnetic field. It is probable also that the radiation emitted from these eruptions produces effects in the Earth's upper atmosphere which have not yet been investigated.

A member of the staff of the Division of Physics has developed a theory of the origin of chromospheric flares which will give a fresh impetus to research in this field. The theory attributes the phenomena to the electric fields which result from the changing magnetic field of sunspots. The development of the theory required the calculation of the electrical conductivity of the Sun's atmosphere when subject to both the Sun's general magnetic field and the changing magnetic field of a sunspot. The theory predicts the production of intense electric currents and an increase in the ionization and hence the emission of radiation in localized regions in the Sun's atmosphere such as are actually observed. It accounts for the majority of the well-known features of flares, including their occurrence in the Sun's chromosphere, their stationary nature, their sudden beginning and their correlation with the rate of growth of sunspots, and the amount of radiation emitted.

This work has also led to studies of the excitation conditions of the hydrogen which constitutes the bulk of the Sun's atmosphere. The proportions which have been raised to the various atomic energy levels of hydrogen have been calculated and the results applied to predict the intensities of the hydrogen spectral lines $H\alpha$, $L\alpha$, and $L\beta$ at various heights and temperatures in the Sun's atmosphere.

It is shown also that at heights above 500 kilometres in the Sun's chromosphere practically all hydrogen atoms are ionized and hence the electron density is the same as the hydrogen density. Further, in good agreement with the temperatures derived from spectroscopic observations, the temperature of the lower chromosphere is found by calculation to be of the order of 2.7×10^4 degrees Kelvin.

These investigations have opened the way to the study of further problems concerning solar phenomena, which will be continued in the forthcoming year.

5. Radio Stars.

One of the outstanding discoveries of last year was the existence of a number of discrete sources of stellar noise—radio stars. At the time of our last report seven such sources had been found and none of them at that time could be identified with known stars.

The method of locating radio stars was to observe them rising over the sea by means of a sensitive radio receiver placed on a high cliff near Sydney. This site was the best available on the New South Wales coast but did not allow their positions to be fixed with sufficient accuracy. An expedition was, therefore, sent to a special site in New Zealand which, among other things, allowed measurements on these stars to be made as they were both rising and setting over the sea. As a result of the New Zealand observations, the number of known radio stars was increased to 21 and their positions determined to a fair order of accuracy. Three of them can be identified with objects which can be seen prominently in the sky. All three are nebulae, perhaps the most interesting being the Crab Nebula. This is a unique object in the sky, a body which is expanding so rapidly that it can be seen doing so. It is believed to be the remains of a star which exploded and was observed as a supernova by Chinese astronomers about the year 1,000 A.D.

6. Galactic Noise.

In addition to radio noise from discrete stellar sources, radio waves are received from the matter which is distributed throughout our galaxy. A detailed survey of galactic noise received on a wavelength of 3 metres has been made. This is the first of its kind which has been done in the southern hemisphere and, in conjunction with a similar survey of the northern hemisphere, provides a comprehensive picture of the distribution of cosmic noise over the celestial sphere. This information is expected to lead to a determination of the structure of the galaxy because radio waves can penetrate the great clouds of inter-stellar dust which prevent light from the central regions of the galaxy from reaching the Earth.

XXVII. ATOMIC PHYSICS.

1. General.

The Organization is co-operating with the University of Melbourne in a programme of research on nuclear physics and cosmic rays under the direction of Professor L. H. Martin. Both activities have a common aim, namely the study of the forces within the nucleus of the atom, but while the first uses high-speed particles artificially produced in the laboratory, the latter analyses the disintegration produced in the upper atmosphere by high-speed particles reaching the Earth from outer space. Work on these projects is described in Sections 2 and 3 below.

Co-operative investigations on cosmic rays are also being undertaken at the University of Tasmania under the direction of Professor A. L. McAulay. This work is described in Section 4 below.

In collaboration with the Commonwealth Department of Health, arrangements have been made to procure supplies of radioactive isotopes from overseas and to develop a service for their handling and dissemination to research workers in Australia. The work on tracer elements investigations is described in Section 5 below.

2. Nuclear Physics.

(*a*) *Million-volt Electrostatic Generator.* — A 1,000,000-volt electrostatic generator has been operating regularly since July, 1948. Methods of controlling the potential to 0.2 per cent. between 300 and 800 kilovolts and to 0.5 per cent. above 800 kilovolts have been developed. Electronic devices have been designed to stabilize the potential applied to the accelerating tube and the current which energizes the electromagnet that resolves the ion beam. The potential meter of the generator has been calibrated against gamma ray resonances in lithium and fluorine.

The asymmetry in the angular distribution of -particles from the Li^7 (p,α) He^4 reaction has been etermined for incident proton energies between 130 eV. and 960 keV., using nuclear emulsion plates in a amera which permits observation of α-particles in the ngular range 13° to 90° and 167° to 90° to the ncident proton beam. This work is now being ublished.

The photographic plate measurements involved in his research covered a total of more than a quarter of million α-particle tracks.

An investigation of the angular distribution of protons from the H^2 (d, p) H^3 reaction is proceeding using the method described above. Preliminary work has indicated certain necessary refinements in experimental technique.

The neutron spectra and the angular distribution of neutrons from the reaction Be^9 (d, n) B^{10} are to be determined from measurements on proton recoil tracks obtained in nuclear research emulsions exposed at various angles to the deuteron beam incident on a beryllium target. A preliminary investigation is being made to see whether neutron scattering in the target assembly and surroundings is a serious factor.

(*b*) *Neutron Generator—Scattering Experiments.*—The redesigned neutron generator, using a horizontal acceleration tube and target at earth potential, operates at 200 kV. with an ion beam current of 150 micro-amperes. It employs the D–D reaction, the target being heavy paraffin cooled continuously with a stream of refrigerated air.

An automatically operated expansion chamber is being used to determine the angular distribution of recoil protons produced by 3 MeV. neutrons from the neutron generator. A similar experiment will be carried out with recoil deuterons. The distribution of the recoil particles depends on the nature of the binding forces between the proton and the neutron. Forces of the "exchange" type have been observed recently in collisions between very fast neutrons and protons and the present experiments are being made in the attempt to detect the presence of these with neutrons of 3 MeV. energy. The deuteron problem is significant since the bombarding neutrons have energies of the same order of magnitude as the known binding energy of the proton and neutron which compose the nucleus of deuterium. Precise determination of the asymmetry of the angular distribution of the recoil deuterons should provide decisive information on the existence of "exchange" forces in this nucleus.

(*c*) *Electron Synchrotron.*—It is expected that this machine will be operating late this year. Certain portions of the equipment have been assembled and tested. The magnet and excitation system function satisfactorily at the 12 MeV. level. Field tests show that focusing and symmetry are satisfactory, and indicate that disturbances arising from quadrature fields will not be large. The vacuum system is complete and electronic control and injection circuits are operating. The radio-frequency system still requires considerable work.

The immediate objective is to have the machine functioning well as a 4 MeV. betatron; the ultimate aim is to have it operating as a 20 MeV. synchrotron.

The radiation from this machine will be used to study problems of photo-disintegration and pair production. Study of the laws of absorption of this very penetrating radiation should be useful in the technical field of radiation fluoroscopy, especially of heavy metal sections.

3. COSMIC RAY STUDIES.

(*a*) *The Structure of Cosmic Ray Air Showers.*—The study of cosmic ray showers with coincidence ionization chambers is being continued and extended with the aid of simultaneous records obtained with Geiger counter equipment, which will distinguish between the various factors responsible for the bursts of ionization in an ionization chamber. The results show that rather more than one-half of such bursts are due to nuclear disintegrations, about 3 per cent. to extensive showers, and the remainder to narrow showers, i.e. showers covering only a very few square metres. Further work is in progress to determine the nature of these narrow showers. The theoretical aspect of this work is also being investigated. Details of experimental results are in course of publication.

(*b*) *Cosmic Ray Spectrometer.*—The spectrum of the high-energy cosmic ray particles is to be analysed by measuring the curvature of their paths between the pole pieces of a 3-ton magnet, the paths of the particles being determined by allowing them to pass through trays of Geiger counters placed above and below the magnet. By means of associated electronic equipment the results are recorded automatically on a punched card system. The spectrometer will measure energies up to a maximum of 7×10^{10} eV.

Preliminary measurements have been made of the scattering of mesons in their passage through the counter telescope and are found to agree within 1 per cent. of the theoretically predicted distribution. At present the first studies are being conducted on the energy distribution of mesons which have sufficient energy to penetrate at least 10-cm. lead.

(*c*) *Mean Life of the Meson.*—An apparatus has been almost reconstructed for magnetically sorting out positive and negative mesons and determining their decay times, which are of the order 10^{-6} second, to an accuracy of 10^{-8} sec. At the same time the range of the decay electrons will be measured, and their energies deduced. The energy of the decay electron throws light on the details of the meson decay process, a problem as yet unsolved. This research has required the development of pulse amplifiers for rise times of the order 10^{-8} second, decay lines, and parallel-plate counters.

(*d*) *Antarctic Expeditions.*—The expeditions to Heard Island and Macquarie Island and the *Wyatt Earp* survey voyage have provided data on cosmic ray showers, the statistical analysis of which is approaching completion. A survey voyage to Japan and back has also provided interesting results on the latitude effect. Improved Geiger-Muller counting equipment, and an ionization chamber with a new type of recording electronic electrometer, have been constructed for further work on the Islands and along the east coast of Australia.

4. COSMIC RAY STUDIES—HOBART.

The earlier measurements of the high latitude east-west asymmetry at Hobart were made with a single Geiger counter telescope at a zenith angle of 45°. Further measurements have been made using a double telescope at 60°. Measurements have been made with no lead, with 12.5 cm. lead, and with 24 cm. lead.

The aim is to obtain data to test Johnson's theory of the asymmetry at high latitudes. In the course of the work evidence has been found for an anomalous absorption of mesons by the lead as was suggested earlier by Seidl, and this is being examined further.

It is proposed to construct larger apparatus to permit results to be obtained more rapidly.

5. Tracer Element Investigations.

The activities have been widened by the addition to the staff of a chemist, for such work as the synthesis of isotopically-labelled materials needed for various tracer investigations, and the processing of radioactive materials before assay.

Shortage of laboratory space has been a major difficulty, but Professor Hartung has kindly made space available for chemical work in the Chemistry Department of the University of Melbourne.

(*a*) *Procurement and Distribution of Isotopes.*—Supplies of radioactive isotopes have been obtained from the Atomic Energy Commission and from cyclotron production in the United States. English pile production has now increased to a stage where alternative supplies of some materials are available from the Atomic Energy Research Establishment at Harwell, and trial shipments to Australia are to be made shortly.

During the year 48 shipments of eight different isotopes have been distributed for medical use to the Commonwealth Department of Health and for research applications to various divisions of the C.S.I.R.O., the Defence Research and Industrial Laboratories, the Victorian Department of Agriculture, and the Chemistry Departments of the Universities of Melbourne and Western Australia.

(*b*) *Radio-iodine in the Thyroid.*—Radio-iodine is finding increasing use for the diagnosis of some thyroid conditions. Pilot experiments have been carried out with Dr. R. Kaye Scott at the Royal Melbourne Hospital, and 24 patients have been examined with methods and measuring apparatus specially developed for the purpose. Similar equipment is being installed at four hospitals in other States.

In connexion with this work a mathematical analysis has been published for the rates of metabolism of tracer-iodine in the human body, and the practical methods and results are being described in two later papers.

(*c*) *Labelled Compounds.*—Methionine labelled with radio-sulphur is being prepared for the Division of Entomology, and iodine is being incorporated in a compound akin to 2,4-D for tests by the Division of Plant Industry.

(*d*) *Trace Elements in Plants.*—Preliminary pilot experiments have been carried out with the Victorian Department of Agriculture using radio-manganese to study manganese-molybdenum antagonism in plants.

(*e*) *Radioactive Assay.*—Progress has been made in developing standardized methods and equipment for the assay of radio-elements most commonly used in tracer work. Six standard lead castles and Geiger tube mountings have been constructed and calibrated for different users.

Routine assays are made of shipments of P^{32} and I^{131} received for medical use, and the absolute measured strength is in satisfactory agreement with that measured in the United States of America. Intercomparisons of standard solutions of I^{131} have been arranged from time to time with the United States National Bureau of Standards.

Stocks of Geiger counter tubes and other assay equipment are maintained for issue to research organizations as needed. During the year sets of counting apparatus for measurement purposes have been lent to four laboratories over periods limited to about two or three months.

(*f*) *Information.*—Lists of references on seven special subjects have been issued this year in continuation of the nineteen lists prepared during 1947-48. In addition, further lists have been prepared, when requested, for workers engaged in special fields of research.

XXVIII. MATHEMATICS.

1. General.

Mathematical work naturally plays an important part in all phases of the Organization's research programme.

For many years past a separate Section of Mathematical Statistics has been maintained to provide workers in the various Divisions and Sections with special help in planning their researches and analysing their experimental results. The work of this Section is described in Section 2 below.

More recently, work has been undertaken within the Division of Electrotechnology (*see* Section 3 below) and the Division of Radiophysics (*see* Section 4 below) on mathematical instruments and mechanical and electrical methods of computation. The small group working in this field in the Division of Electrotechnology has now been transferred to work as an independent Section of Mathematical Instruments under the leadership of Professor D. M. Myers in the Electrical Engineering Department of the University of Sydney.

2. Section of Mathematical Statistics.

In its main function of advising in the many projects of the Organization, the Section has continued to provide assistance with long-range experiments, and has undertaken additional work, including several large-scale trials involving considerable preparation and routine analysis. This work is not described here as the various projects have been discussed in detail in other chapters of this Report. In this capacity also, experiments have been designed, and subsequent results analysed, for many external organizations, including University research teams, Commonwealth and State departments, and commercial enterprises. In addition, a good deal of time has necessarily been spent in lecturing, both to junior Sectional staff as part of their course of preliminary training, and to graduate and undergraduate classes in the Universities with which the Section is closely associated. The Section's own research programme, which it is hoped to extend as fresh staff is obtained, has made steady progress. The primary analysis for determining the expectation of monthly rainfall in South Australia is complete, and the results are now being illustrated graphically on a series of maps. The work is being extended to establish the relationship between variability of rainfall within zones of equal mean rainfall, and plant ecology, and to assess the probabilities of drought of varying intensity and duration.

In the previous Report it was mentioned that the investigation of the trend in yield throughout the wheat belt of South Australia during the period 1913-1937 had been completed. As a natural outcome of this work, the analysis has been extended to cover the period 1896-1941. This work is described in detail in Chapter III., Section 24.

3. Section of Mathematical Instruments.

(*a*) *Differential Analyser.*—Construction of the differential analyser has proceeded very slowly during the year, mainly because of the high order of mechanical precision required for the manufacture of the main components, and the inevitable shortages of labour and material. However, some progress has been made and an "interim" differential analyser consisting of two integrators, the adding units, three gear boxes, and four plotting tables, has been assembled. A limited range of problems may be solved on this machine, and considerable benefit is being derived from the facilities it offers for gaining experience in its operation.

The present plan for the first machine provides for en integrators, six adding units, twelve gear boxes, our plotting tables, a central control board, and a rinting unit.

(*b*) *Course Plotter.*—The course plotter, designed to lot automatically and continuously the course of a ehicle in which it is mounted, and fitted with a gyro tabilized magnetic compass unit, was completed this ear. A more robust alternative compass unit of the lux-gate type has also been developed.

(*c*) *Digital Computers.*—The experience gained in ulse generation, counting, and gating for digital comuters has been applied to the development of an lectrostatic storage unit. This storage unit is similar o the one developed at Manchester by Williams and Kilburn. A standard cathode ray tube is used and ignals in the form of " dots " and " dashes " are stored n the fluorescent coating of the tube. The single lectron beam of a standard tube is used for writing, eading, and regeneration of the signals. An experinental model is at present working satisfactorily. Work is being carried out on the development of input nd output register. Preliminary attention is being aid to the general design of a complete computer mploying the electrostatic storage tube for memory, he binary and coded decimal system of numbers, and a parallel method of operation.

4. Mechanical and Electrical Computation Methods.

In carrying out its programme of research, particularly in the fields of tropospheric and ionospheric propagation, the antenna theory of long waves, and the coalescence of raindrops, the Division of Radiophysics has found it necessary to make considerable use of mechanical and electrical computation methods. Progress has been made in the adaptation of automatic punched card equipment for these purposes and in the design of a special electronic calculating machine.

(*a*) *Adaptation of Existing Machines—National Accounting Machine.*—This machine was ordered some time ago and arrived during the year. It has been used extensively for obtaining tables of difference, for sub-tabulation, integration, &c. Methods have been devised for its use in solving ordinary differential equations and it has been employed in the solution of simultaneous differential equations. It has also been used in statistical work for other Divisions of the Commonwealth Scientific and Industrial Research Organization.

(*b*) *Adaptation of Existing Machines—Hollerith Punched Card Equipment.*—A range of Hollerith punched-card equipment, including a reproducer, a tabulator, a collater, and a sorter, was received in April, 1949. This machine was designed originally for business accounting purposes, but it is surprisingly well suited to carrying out a great variety of mathematical operations. The full scope of the machine for this purpose has not yet been properly explored. In the few months that it has been available several numerical problems have been attacked and preliminary tests have revealed the utility of the equipment and its flexibility for scientific purposes. It is proposed to continue using the machine for the solution of problems by known methods and to explore other ways in which it may be used for mathematical purposes.

(*c*) *Design of Electronic Computer.*—In addition to work with existing computing equipment, the Division is designing an electronic machine which it is hoped may have many advantages over the mechanical types. The computer is of the digital type operating on the binary system. The overall design characteristics have been laid down and progress made on the construction of many of the units. The basic control gear required for performing a sequence of instructions has been assembled, a reliable memory system making use of mercury delay lines has been developed, and the final stages of construction of the computing unit are in hand. It is hoped shortly to begin tests of the computing machine and to carry out some trial computations.

In the first stage the machine will be capable of performing addition, subtraction, sign questioning, &c., while units for multiplication and division will be added later. Punched card methods will be used to feed data into the machine, and for accepting the solution.

XXIX. INFORMATION AND LIBRARY SERVICES.

1. General.

It is obviously of great importance to see that the results accruing from the Organization's research programme are made available to those who are interested in their application to the problems of industry.

Research results are published through a variety of scientific journals catering for the special needs of the various branches of scientific endeavour, including specialist journals published overseas. The Organization itself publishes, in collaboration with the Australian National Research Council, the *Australian Journal of Scientific Research,* which is issued in two series, Series A dealing with physical sciences and Series B with the biological sciences. It is also establishing two new journals: the *Australian Journal of Applied Science* and, in collaboration with the Australian Institute of Agricultural Science and the Australian Veterinary Association, the *Australian Journal of Agricultural Research.* Longer reports are published in the Organization's Bulletin series.

The Divisions and Sections maintain close contact with the various branches of industry interested in their particular research projects. In the case of agricultural research, direct contact with the man on the land is difficult but the extension officers of the various State Departments of Agriculture help to bridge this gap. An endeavour has been made to keep State officers advised of research progress, for example, through the medium of special schools dealing with particular subjects.

Various series of trade circulars and newsletters are issued to provide industry with technological information and articles of a similar nature are prepared for trade publications. The Organization has also collaborated with other bodies, for example, the Australian Wool Board and the Australian Dairy Board, in the preparation of special pamphlets dealing with its research results.

The information officers and technical secretaries attached to various Divisions and Sections give a great deal of help to industry by answering specific inquiries either from the accumulated experience of the scientific staffs of the laboratories or from the literature. They are assisted in this work by the central Information Service established at the Organization's Head Office (*see* Section 2 below).

To enable the scientific staff to keep up to date with overseas research, special library facilities have been built up, both at the Head Office and within the Divisions and Sections (*see* Section 3 below). The Information Service is able to give valuable assistance with this work, particularly through its Translation Section.

As far as possible, direct contact is maintained with workers in overseas laboratories. This is helped considerably by visits overseas by members of the scientific staff, although the number of officers who can be sent for this purpose is rather limited. The liaison offices in the United Kingdom and North America are able to assist in following up specific inquiries and in facilitating the visits of members of the research staff (*see* Section 4 below).

2. INFORMATION SERVICE.

Early in the period, the Information Service moved to the Head Office buildings, where accommodation had become available. This has enabled it to be more closely co-ordinated with other units under the control of the Secretary. The Information Service is now concerned with the implementation, so far as Australia is concerned, of the recommendations made by the Royal Society Scientific Information Conference of June-July, 1948.

Preliminary action has been taken towards the compilation of a "Handbook of Australian Scientific and Technical Institutions and Societies".

(*a*) *Information Section.*—(i) *Inquiries.*—During the past year there has been a steady increase in the number of major inquiries received. The nature of inquiries has been very much the same as in the past—most were concerned with technological problems.

During the year over 3,500 inquiries have been handled, representing an increase of about 8 per cent. over 1947-48. Approximately 1,360 of these—about the same number as for last year—were dealt with summarily by telephone or at personal interviews. It is of interest that the subject distribution of inquiries was almost identical with that of 1947-48.

The Information Section has continued to work in close collaboration with the Technical Information Section of the Defence Research Laboratories. The Division of Industrial Development of the Department of Post-war Reconstruction is now referring a constantly increasing number of requests for technical assistance.

(ii) *Bibliographies and Summaries of Information.*—Twenty-eight bibliographies and summaries of information were prepared during the year and selected lists have, as before, been published in appropriate technical and trade journals.

(iii) *Australian Chemical Abstracts.*—During the year Information Service officers have prepared about 250 abstracts covering material of chemical interest appearing in Australian periodicals. The arrangement made with the Technical Information Service of the Defence Research Laboratories, whereby the latter service undertook responsibility for abstracting material of metallurgical interest in Australian periodicals, is now in operation, and a number of metallurgical abstracts was published during the past year.

At the request of the Bureau of Abstracts, London, the Information Service has undertaken to supply the Bureau with copies of *Australian Chemical Abstracts* in order to speed up the Bureau's coverage of Australian journals.

(*b*) *Sydney Office.*—During the year, 1,132 inquiries were received—an increase of about 16 per cent. on the previous year. About 630 inquiries were dealt with summarily by telephone. The remainder required more extensive action and of these about 11 per cent. were referred to the Melbourne Office and about 40 per cent. to the Divisions and Sections, Defence Research Laboratories, or other suitable authorities.

Arrangements were recently completed for the employment of a translator on a part-time basis. This will facilitate the use of oral translation, as in the Melbourne area, and it is anticipated that a more effective service will now be possible.

(*c*) *Translation Section.*—During the past year the work of the Section has increased and after some considerable difficulty additional staff has been engaged. Staff shortages have emphasized the desirability of using oral translation whenever practicable in cases where a written translation is not essential.

Another move towards economy of effort has been a revision of the service given in the preparation and distribution of contents sheets and summaries from Russian scientific and technical periodicals. The number of journals so handled has been reduced to twelve and the translation of summaries has been discontinued. This economy has been possible without appreciably impairing the service because abstracts of practically the entire content of these periodicals now appear, though after some delay, in *Chemical Abstracts* and *British Abstracts* and these are usually of more value to scientific workers than translations of the Russian summaries.

During the year the panel of translators (a list of private translators qualified to translate from a large number of languages in many branches of science and industry) was revised. This panel was constituted in the first place for the assistance of non-C.S.I.R.O. personnel, but since it covers certain languages outside the scope of the Translation Section, a circular giving particulars of the panel has been distributed within C.S.I.R.O. as well as to certain government departments. The languages at present handled by the Translation Section are German, Dutch, Swedish, Norwegian, Danish, French, Italian, Spanish, Portuguese, Russian, Polish, Ukrainian, and Lettish. By using the panel, it can also handle Japanese, Hungarian, and Lithuanian.

(*d*) *Cine-photography Section.*—The demand for complete films covering general and particular aspects of C.S.I.R.O. research work has increased. In the extension field, release of the film "Irrigation Research, New South Wales" was quickly followed by a request from the New South Wales Government that the Section should produce a series of films for use by the Extension Service of the New South Wales Department of Agriculture.

Unfortunately, the Department of Information has not so far been able to undertake sound recording and printing for the Section, its facilities being fully occupied with its own productions, but it now appears that the position will improve shortly. On all other aspects of production close touch has been maintained with the Producer-in-Chief of the Films Division of the Department of Information.

During the year the following 16-mm. films were completed:—"C.S.I.R. 1949, Part I.—Primary Industry Research", "Glas II.—Suction Stabilized Wing", "Structural Fatigue and Air Safety", "Current Overseas Building Practice", "Experimental Hut", "Canning Practice—Retorting".

Work is in hand on the following films:—"Northern Australia Reconnaissance Survey Part 2—Barkly Tableland Area", "C.S.I.R.O. 1949, Part 2—Secondary Industry and Physical Sciences", "Caulking Compounds and their use in Modern Building Construction", "The Aims of Irrigation", "The Importance of Flow in Furrow Irrigation", "Purse Seining".

Whenever possible, film strips or slides are now being produced at the same time as the film. This entails very little extra work, and permits lecturers to enlarge on subjects of salient importance or to give some prescreening explanatory talk to audiences who might otherwise not grasp the significance of the film at one showing.

The Section is building up a library of films on ientific subjects, produced by scientific and research ganizations overseas, and presented to C.S.I.R.O.

(*e*) *Central Information Service Activities.*—(i) *issemination of Information from Overseas.*—The neral plan outlined in the previous report has been eveloped and appropriate special mailing lists for e various subject groups have been built up. Material eceived from overseas includes unpublished reports, any of which are furnished by the British Commonealth Scientific Office. Reports made by British, outh African, Canadian, and New Zealand Liaison fficers are thus available for distribution in Australia.

In addition to material which the Information ervice itself receives from overseas, it is kept informed f material forwarded direct to Divisions and Sections, hich is, if desirable, included in the accession lists. y scanning carbon copies of requests sent to the verseas Liaison Offices, it is possible to provide more apidly information required and to avoid unnecessary r duplicated calls on the Liaison Officers.

Quite often, distribution of information in this way timulates interest and requests for further information which is obtained either locally or from overseas. The Information Service is also collecting suitable unpublished information of Australian origin and ending it to the overseas liaison offices for distribution.

(ii) *Published Bulletin Reports.*—The publication, n Australian scientific and technical journals, of elected abstracts of reports of war-time research taken rom the United States Department of Commerce Bibliography of Scientific and Industrial Reports has continued. As many of the titles listed in recent issues of the Bibliography have been of reports in German text, the number of requests for procurement has been decreasing. As previously, the majority of requests has involved procurement from the United States of America, while the balance has been satisfied from local sources, including the Division of Industrial Development's holdings of reports on German industry.

Informative abstracts rarely appear in current issues of the Bibliography. For this reason, and also because it is considered that those interested are by now familiar with this source of information and reference copies are available in central libraries, the publication of selected abstracts has recently been stopped. The Information Service will continue to afford facilities for procurement of P.B. reports as previously. In all, about 11,000 abstracts were sent to journals for publication, 2,541 reports ordered to date from U.S.A. via A.S.R.L.O., Washington, the balance requested, amounting to 1,011, having been provided from local sources.

(iii) *Declassification of Reports of Australian Wartime Research.*—Consultation with the Service Departments with a view to the declassification of reports of Australian war-time research has been continued and the majority of these are now unclassified.

(iv) *Industrial Information Advisory Committee.*—This Committee, which held nine meetings during the period, continued to make an effective contribution to the close collaboration of its constituent organizations. The regular meetings have provided a useful clearing point for problems which arose in connexion with the supply of scientific and technical information to Australian industry. It has been found practicable to work together and to avoid duplication of services, which otherwise would inevitably develop. Such basic co-operation is invaluable when planning development of the existing services.

(*f*) *Commonwealth Agricultural Bureaux.*—During the year a meeting of the Official Correspondents with the C.A.B. Liaison Officer was held and all aspects of the C.A.B. Organization were discussed in relation to its development and its value to Australian workers.

The free quota mailing lists for all C.A.B. journals were revised during 1948 to improve the overall distribution of journals. In making the new allocations the need for maintaining existing sets was kept in mind and also the need for placing these free copies in libraries where they will have the greatest value to workers and especially to students. A recent analysis of subscription lists has shown that the number of subscription copies taken in Australia has increased by more than 80 per cent. since 1946.

The procurement of technical communications, bulletins, and occasional papers has been difficult in the past as it has been necessary to order from the United Kingdom and to forward sterling drafts. During the year, arrangements have been made to import bulk supplies of these direct from the press and to make them available for purchase at the Australian equivalent of English prices. The numbers sold, averaging more than 60 volumes per month, suggest that this service is appreciated.

(*g*) *Dairy Production Abstracts.*—The publication of these abstracts was suspended after June, 1948, pending review by the Australian Committee on Animal Production. The Committee has recently decided that publication should be resumed and the Technical Subcommittee on Dairy Cattle Production and the Publication Committee will explore the possibility of developing an improved publication.

(*h*) *Phytochemical Register of Australian Flora.*—The trial compilation referred to in last year's report covering the family *Rutaceae* was made and, using this as a basis, an estimate of the work likely to be involved in a comprehensive survey was prepared. It has been decided that the Information Service could not undertake the preparation of a register as originally conceived, but that it should set up a repository for information to be compiled and supplied by volunteer assistance. To assist in this work a standing advisory committee has been set up, and a detailed "modus operandi" is now being worked out.

3. LIBRARIES.

The work of the Organization's libraries has continued during the past year along the same lines as previously. The foreign journal holdings in the libraries are extensive. Although some of them are received by subscription, many more are offered in exchange for the Organization's own publications. The appearance of the *Australian Journal of Scientific Research* has added considerably to the value of the exchanges which the organization has to offer and, in consequence, it is receiving without cost many foreign journals and other publications which would otherwise be difficult to procure. These publications are, of course, available to any one requiring to see them.

German scientific publications are again becoming available. German journals have recommenced publication in some cases under their own titles, whereas others have amalgamated and resumed publication in a new series. The Organization is subscribing to, and receiving, many of these journals.

Apart from the usual activities, the main interest during the year has been the return from overseas of a member of the Library staff who had been studying improved methods of library technique in England and America. On the whole, it seems that the Organization is not much, if at all, behind these countries in its Special Library methods and, as one would expect, it is largely a question of the size of the library which governs the advisability of using complicated mechanized systems for library recording.

The possibility of adapting cataloguing practices to the use of the unit card and its duplication by mechanical means is being investigated. There are various methods of card duplication and it has yet to be decided which is the most economical and satisfactory for use both in the larger of the Organization's libraries and in the smaller Sections.

Another question in which much interest is being taken overseas is punched-card methods for general library records and for bibliographical indexing. It seems that mechanized punched-card systems for use in loan and order records are not suitable for any but very large libraries, and even here they are not always considered successful. It is not intended, for the present at any rate, to use them here although a simple punched-card system with marginal holes and needle sorting is already in use for periodical order files and is proving satisfactory. A more elaborate punched-card system for bibliographical indexing is under discussion for trial in a Sectional library where it is desired to maintain, in conjunction with research associations in other parts of the world, a comprehensive index to the world's literature on textiles.

The effective disposal of duplicate publications is a problem with which all librarians are faced sooner or later. This type of material accumulates quickly and suitable accommodation for it is always limited. However, no librarian likes to send to waste-paper depots publications which are at all likely to fill gaps in another librarian's files. A determined effort has been made this year to organize a duplicate pool at Head Office Library. The material is gathered there, sorted, and listed, and the lists are then sent out to all Divisional Librarians. The result has been good and many gaps in holdings in Divisional libraries have been filled from the pool. It is intended, at a later date, to issue the lists to other technical libraries in the hope that they may also be assisted in completing their volumes.

The revised edition of the *Catalogue of Scientific and Technical Periodicals* has not yet appeared and the delay is much to be regretted, but is due to the difficulties of publication. It is still impossible to say when the Catalogue is likely to be available for distribution.

4. Overseas Liaison Offices.

The Organization maintains Scientific Liaison Offices in London and Washington. These form constituent units of the British Commonwealth of Nations Scientific Office (London) and the British Commonwealth Scientific Office (North America) respectively. These joint offices provide common facilities for Scientific Liaison Officers from the different Dominions to work together in London and Washington.

The C.S.I.R.O. Liaison Offices were originally set up during the war for the collection of information on radar and similar subjects. They now serve a number of important functions which include the carrying out of inquiries for C.S.I.R.O. Divisions and Sections, the location and collection of unpublished reports, and the general facilitating of the interchange of information. They also act as bases for C.S.I.R.O. officers overseas and a point of contact with research students. In addition, they procure specialized equipment and apparatus and generally act as a link for the Organization with scientific work in the United Kingdom and North America.

XXX. FINANCE, STAFF, PUBLICATIONS AND COMMITTEES.

1. Finance.

The statement of expenditure from 1st July, 1948, to 30th June, 1949, is as follows:—

			£
(*a*) Salaries and contingencies			142,216*
(*b*) Remuneration of Chairman and Members of the Council for Scientific and Industrial Research			3,223†
(*c*) Investigations—		£	
(i) Animal Health and Production Problems		217,247	
Less contributions from—	£		
Wool Industry Fund	4,676		
Wool Research Fund	73,760		
Commonwealth Bank	2,700		
Queensland Government	1,000		
Australian Cattle Research Association	3,750		
Australian Meat Board	2,088		
Australian Wool Board	12		
Ian McMaster Bequest	557		
Alexander Frazer Memorial Fund	300		
Burdekin Bequest	2,692		
Revenue Funds—			
Regional Pastoral Laboratory, Armidale	3,500		
Burdekin Bequest	253		
McMaster Field Station—Dairy	369		
Poultry Breeding	2,906		
Parkville	166		
Vaccine	1,084		
Contagious Pleuro-pneumonia	1,278		
Tooradin Field Station	1,000		
Parisitology—McMaster Laboratory	463		
Oestrus	409		
Toxaemic Jaundice—Barooga	479		
Mastitis	1,043		
McMaster Field Station	1,427		
"Gilruth Plains" Field Station	9.789		
		115,701	
			101,546

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* The main items of expenditure under this heading are salaries of the Administrative Staff at the Organization's Head Office; salaries and expenses of officers at the Liaison Offices in London and Washington: staff and upkeep of State Committees; travelling expenses of Head Office Staff; and printing and general office expenditure.

† Provided from Consolidated Revenue Fund.

	£	£	£
(ii) Biochemistry and General Nutrition Problems	..	81,553	
Less contributions from—			
Commonwealth Bank	900		
Wool Research Fund	14,539		
Wool Industry Fund	29,757		
		45,196	
			36,357
(iii) Plant Problems—Division of Plant Industry	..	204,662	
Less contributions from—			
Tobacco Fund	3,923		
Department of Post-war Reconstruction	6,611		
Western Australian Golf Association	197		
Wool Industry Fund	6,916		
Wool Research Fund	29,399		
		47,046	
			157,616
(iv) Entomology Problems	..	70,318	
Less contributions from—			
Wool Research Fund	211		
		211	
			70,107
(v) Horticultural Problems of the Irrigation Settlements—			
(*a*) Citricultural—Research Station, Griffith	42,254		
Less contributions from—	7,993		
		34,261	
New South Wales Water Conservation and Irrigation Commission	2,630		
New South Wales Department of Agriculture	1,135		
Rural Bank of New South Wales	1,442		
Yenda Producers' Co-operative Society Limited	84		
Griffith Producers' Co-operative Company	252		
Leeton Fruit Growers' Co-operative Company	84		
Leeton Co-operative Canneries Limited	504		
Rice Equalization Association Limited	210		
Rice Marketing Board	210		
Griffith Research Station Revenue Fund	1,442		
(*b*) Viticultural—Research Station, Merbein	20,767		
Less contributions from—	3,789		
		16,978	
			51,239
Dried Fruits Control Board	1,600		
Mildura Co-operative Fruit Company	180		
Irymple Packing Company	181		
Red Cliffs Co-operative Fruit Company	181		
Aurora Packing Company	181		
Merbein Station Revenue	1,466		
(vi) Soil Problems	..	46,944	
Less contribution from—	2,000		
Commonwealth Bank		2,000	
			44,944
(vii) Food Preservation and Transport Problems	..	64,724	
Less contributions from—			
Commonwealth Bank	2,400		
New South Wales Department of Agriculture	1,149		
Metropolitan Meat Industry Commission	500		
Queensland Meat Industry Board	850		
Australian Meat Board	375		
William Angliss Grant	136		
Australian Egg Board	100		
Egg Investigations Revenue Fund	59		
Food Preservation Revenue Fund	158		
		5,727	
			58,997
(viii) Forest Products Problems	..	128,837	
Less contributions from—			
Australian Paper Manufacturers Limited	500		
Associated Pulp and Paper Mills Limited	500		
New Zealand Forest Products Limited	250		
Australian Newsprint Mills Limited	500		
Commonwealth Bank	2,000		
Beetle, Elliott Plastics Proprietary Limited	169		
Australian Dairy Council	11		
Miscellaneous contributions	13		
Forest Products Revenue Fund	291		
		4,234	
			124,603
(ix) Mining and Metallurgy	..	12,690	
Less contributions from—			
Australasian Institute of Mining and Metallurgy	500		
		500	
			12,190
(x) Radio Research	..	16,274	
Less contributions from—			
Postmaster-General's Department	4,500		
Departments of Army, Navy and Air	7,087		
		11,587	
			4,687

	£	£	£
(xi) Research Services			31,038
(xii) Industrial Chemistry		161,874	
Less contributions from—			
National Gas Association	600		
Cement and Concrete Association	1,500		
Wool Industry Fund	3,167		
Alfred Lawrence and Company	101		
		5,368	
			156,506
(xiii) Fisheries Investigations		90,053	
Less contributions from—			
New South Wales Department of Chief Secretary	250		
Oyster Revenue Fund	150		
		400	
			89,653
(xiv) Aeronautical Research			10,128
(xv) National Standards Laboratory		195,045	
Less contributions from—			
Australian Cement Manufacturers	150		
		150	
			194,895
(xvi) Tribophysics			33,663
(xvii) Building Research			81,630
(xviii) Flax Research			18,973
(xix) Radiophysics Research		152,598	
Less contributions from—			
Department of Navy	1,298		
		1,298	
			151,300
(xx) Metallurgical Research			5,842
(xxi) Nuclear Energy Research			31,833
(xxii) Meteorological Research			14,849
(xxiii) Overseas Studentships		24,296	
Less contributions from—			
Wool Research Fund	4,221		
		4,221	
			20,075
(xxiv) Wool Textile Research		41,887	
Less contributions from—			
Wool Research Fund	36,832		
Wool Industry Fund	5,055		
		41,887	
(xxv) Fuel Research			6,997
(xxvi) Miscellaneous—			
(*a*) Mathematical Research		17,424	
(*b*) Dairy Research		8,647	
(*c*) Oenological Research		1,776	
(*d*) Various		13,311	
		41,158	
Less contributions from—			
Australian Wine Board	712		
Victorian Central Citrus Association	26		
Wool Industry Fund	3,000		
		3,738	
			37,420
(xxvii) Unforeseen and Urgent—			
Wild Life Survey		789	
Less contributions from—			
George Aitken Pastoral Research Trust	125		
		125	
			664
Total of Item (*c*)—Investigations			1,637,752
(*d*) Grant to Research Association—			
Leather Research			6,388

2. CONTRIBUTIONS AND DONATIONS.

The following statement shows the receipts and disbursements during the year 1948-49 of the funds provided by outside bodies and recorded in the special account established in 1931, entitled "The Specific Purposes Trust Account":—

	Receipts 1948-49 and balances brought forward from 1947-48.	Expenditure 1948-49.
	£	£
Wool Industry Fund Account	62,370	52,570*
Carried forward	62,370	52,570
Brought forward	62,370	52,570
Commonwealth Bank (Animal Health and Production, Horticultural, Food Preservation and Transport, and Forest Products Investigations)	10,000	10,000
Australian Wool Board (Animal Health and Production Investigations—Sheep Research)	2,509	12
Australian Cattle Research Association (Mastitis Investigations)	3,750	3,750
George Aitken Pastoral Research Trust (Animal Health and Production Investigations)	500	..
Queensland Government Cattle Research (Animal Health and Production Investigations — Sheep Research)	1,000	1,000
Carried forward	80,129	67,332

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* Expended as follows:—Erection of buildings, Armidale—£2,740. Extensions at Cunnamulla—£239. Capital Improvements, Chiswick—£1,698. Erection buildings, Deniliquin—£6,589. Erection building, Trangie—£96. Building, Trangie—£64 Acquisition property, Kojonup—£166. Erection of Biochemistry Laboratory—£3,167. Erection store and garage, Hackney—£38. Erection Nutrition Laboratory—£29,432. Electrical installations, Glenthorne—£286. Purchase and re-erection huts, Geelong—£3,680. Alterations, Maribyrnong—£1,117. Alterations, Gordon Institute, Geelong—£258. Advance on erection Biochemistry Laboratory—£1,500 and Deniliquin Laboratory—£1,500.

	Receipts 1948-49 and balances brought forward from 1947-48.	Expenditure 1948-49.
	£	£
Brought forward	80,129	67,332
ustralian Meat Board (Beef Cattle Research)	408	408
ustralian Meat Board (Toxaemic Jaundice Investigations, Barooga, New South Wales)	1,680	1,679
ustralian Meat Board (Caseous Lymphadenitis Investigations—Animal Health and Production)	412	..
lexander Fraser Memorial Fund	300	300
P.P. Fairbairn (Animal Health and Production Investigations—Foot-rot control)	30	..
state of the late Captain Ian McMaster (Animal Health and Production Investigations)	859	859A
ictorian Central Citrus Association—Citrus Problems (Plant Industry Investigations)	26	26
est Australian Golf Association (Plant Industry Investigations)	197	197
obacco Trust Fund—Prime Minister's Department and Department of Commerce—Tobacco Problems (Plant Industry Investigations)	3,923	3,923
epartment of Post-war Reconstruction—Northern Australia Regional Survey (Division of Plant Industry)	6,669	6,669B
nited Graziers Association of Queensland—Buffalo Fly and Cattle Tick Investigations (Economic Entomology)	172	..
urdekin Bequest (Drought Feeding Investigations)	3,456	3,148C
eetle Plastics Ltd.—Eucalypt Pulp (Division of Forest Products)	223	223D
ew South Wales Water Conservation and Irrigation Commission (Maintenance of Griffith Research Station)	2,000	2,000
urrumbidgee Irrigation Area Executive Committee Project Farm (Griffith Research Station)	100	..
Department of Agriculture, New South Wales (M.I.A. Irrigation Research Extension Service)	1,483	1,136
New South Wales Water Conservation and Irrigation Commission (M.I.A. Irrigation Research Extension Service)	841	633
Griffith Producers' Co-op. Co. Ltd. (M.I.A. Irrigation Research Extension Service)	353	254
Rural Bank of New South Wales (M.I.A. Irrigation Research Extension Service)	1,893	1,443
Yenda Producers' Co-op. Society Ltd. (M.I.A. Irrigation Research Extension Service)	68	68
Leeton Fruit Growers' Co-op. Society Ltd. (M.I.A. Irrigation Research Extension Service)	163	132E
Leeton Co-op. Canneries Ltd. (M.I.A. Irrigation Research Extension Service)	706	506
Rice Marketing Board, Leeton (M.I.A. Irrigation Research Extension Service)	250	212
Rice Equalization Association (M.I.A. Irrigation Research Extension Service)	250	212
Mildura Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	207	207F
Irymple Packing Co. (Dried Vine Fruits Investigations, Merbein)	207	207F
Red Cliffs Co-op. Fruit Co. (Dried Vine Fruits Investigations, Merbein)	207	207F
Aurora Packing Co. (Dried Vine Fruits Investigations, Merbein)	207	207F
Carried forward	107,419	92,188

A. Includes £302 on account of 1947-48 expenditure.
B. Includes £58 on account of 1947-48 expenditure.
C. Includes £456 on account of 1947-48 expenditure.
D. Includes £54 on account of 1947-48 expenditure.
E. Includes £46 on account of 1946-47 expenditure.
F. Includes £26 on account of 1947-48 expenditure.

	Receipts 1948-49 and balances brought forward from 1947-48.	Expenditure 1948-49.
	£	£
Brought forward	107,419	92,188
Dried Fruits Control Board (Dried Fruits Investigations)	1,600	1,600
Nyah-Woorinen Dried Fruits Inquiry Committee (Dried Fruits Investigations)	303	..
Australian Meat Board (Meat Investigations)	500	500G
Metropolitan Meat Industry Commissioner of New South Wales (Meat Investigations)	500	500
Queensland Meat Industry Board (Meat Investigations)	850	850
New South Wales Department of Agriculture (Food Investigations)	1,000	1,000
A. Lawrence and Co. (Division of Food Preservation and Transport)	74	..
W. Angliss Ltd. (Division of Food Preservation and Transport)	174	136
L. Berger and Sons (Division of Food Preservation and Transport)	25	..
Batlow Packing House Co-op. Ltd. (Division of Food Preservation and Transport—Fruit Juice Investigations)	400	..
Ungars Peanuts Pty. Ltd. (Division of Food Preservation and Transport—Canning Investigations)	10	..
Various Contributors (Division of Food Preservation and Transport—Fruit Juice Investigations)	40	..
Egg Producers' Council (Division of Food Preservation and Transport—Egg Investigations)	164	164H
Australian Egg Board—Division of Food Preservation and Transport—Egg Investigations	100	100
New South Wales Department of Agriculture—Quick Freezing of Fruit and Vegetables (Division of Food Preservation and Transport)	202	202I
Australian Paper Manufacturers Ltd. (Paper Pulp Investigations)	500	500
Associated Pulp and Paper Mills Ltd. (Paper Pulp Investigations)	500	500
Australian Newsprint Mills Pty. Ltd. (Paper Pulp Investigations)	500	500
N.Z. Forest Products Co. Ltd. (Paper Pulp Investigations)	500	500J
Bureau of Forestry, Canberra, and Forest Services of Queensland, Victoria, New South Wales and Western Australia—Wood Structure (Forest Products Investigations)	13	13
Sundry Contributions (Forest Products Investigations)	2,219	291
Australasian Dairy Council (Weed Taint in Butter Investigations)	11	11
Miscellaneous Contributors (Division of Forest Products—Veneer and Gluing Work)	8	..
Australasian Institute of Mining and Metallurgy (Mineragraphic Investigations)	500	500
Postmaster-General's Department (Radio Research)	4,500	4,500
Departments of Army, Navy and Air (Radio Research)	9,000	7,087
Sundry Contributions (Foreign Journal Service)	9	..
New South Wales Government (Fisheries Investigations)	250	250
Drug Houses of Australia (Division of Fisheries—Agar Production)	25	..
Commonwealth Fertilizers and Chemicals (Industrial Chemistry)	300	..
Carried forward	132,196	111,892

G. Includes £125 on account of 1947-48 expenditure.
H. Includes £164 on account of 1947 48 expenditure.
I. Includes £53 on account of 1947 48 expenditure.
J. Includes £250 on account of 1947-48 expenditure.

	Receipts 1948-49 and balances brought forward from 1947-48.	Expenditure 1948-49
	£	£
Brought forward	132,196	111,892
National Gas Association (Gas Investigations—Industrial Chemistry)	1,933	600
Australian Cement Manufacturers (Cement Investigations—Industrial Chemistry, Soils)	2,250	2,250K
Australian Cement Manufacturers—Calibrating Cement Testing Equipment (National Standards Laboratory)	150	150
Department of Commerce and Agriculture (Apple and Pear Investigations)	55	Cr. 21L
Department of Navy	1,298	1,298
Sundry Contributors (Commonwealth Scientific and Industrial Research Organization—Publications)	24	..
Various Contributors (Division of Industrial Chemistry)	691	..
Wool Scourers, Carbonizers and Fellmongers Federation of Australia (Division of Industrial Chemistry)	3,000	..
Alfred Lawrence and Co. Ltd. (Division of Industrial Chemistry)	101	101
Various Contributors (Foundry Sands Investigations—Division of Industrial Chemistry)	28	..
Commonwealth Aircraft Corporation (Division of Metrology, N.S.L.)	1,167	..
Australian Wine Board—Oenological Research	741	741M
George Aitken Pastoral Research Trust—Rabbit Investigations	500	125
Revenue Fund—Fleece Analysis Laboratory (Animal Health and Production Investigations)	129	..
Revenue Fund—Toxaemic Jaundice Investigations (Animal Health and Production Investigations)	1,427	..
Revenue Fund—Contagious Pleuro-pneumonia Investigations (Animal Health and Production Investigations)	1,278	1,278
Revenue Fund—Helenslee Field Station (Animal Health and Production Investigations)	451	..
Revenue Fund—Oestrus Experiment (Animal Health and Production Investigations)	1,530	409
Revenue Fund—Sale of Contagious Pleuro-pneumonia Vaccine (Animal Health and Production Investigations)	1,442	1,442N
Revenue Fund—Sale of Strain 19 Vaccine (Animal Health and Production Investigations)	581	..
Revenue Fund—Burdekin Bequest (Animal Health and Production Investigations)	253	253
Revenue Fund—Anaplasmosis Investigations (Animal Health and Production Investigations)	96	..
Revenue Fund—Parkville Laboratory (Animal Health and Production Investigations)	166	166
Revenue Fund—Tooradin Field Station (Animal Health and Production Investigations)	1,517	1,000
Revenue Fund—Poultry Breeding Investigations, Werribee (Animal Health and Production Investigations)	2,906	2,906
Revenue Fund—Werribee Farm Mastitis Investigations (Animal Health and Production Investigations)	4,995	1,167O
Carried forward	160,905	125,757

K. Includes £750 on account of 1947-48 expenditure.
L. Includes £29 on account of 1947-48 expenditure.
M. Includes £359 on account of 1947-48 expenditure.
N. Represents credit on account of 1946-47 expenditure.
O. Includes £124 on account of 1947-48 expenditure.

	Receipts 1948-49 and balances brought forward from 1947-48.	Expenditure 1948-49.
	£	£
Brought forward	160,905	125,757
Revenue Fund—Drought Feeding Investigations, Werribee (Animal Health and Production Investigations)	63	..
Revenue Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Production Investigations)	12,533	10,024P
Reserve Fund—National Field Station, "Gilruth Plains", Cunnamulla, Queensland (Animal Health and Production Investigations)	2,469	..
Revenue Fund—Bacteriological Investigations (Animal Health and Production Investigations)	16	16Q
Revenue Fund—Parasitological Investigations (Animal Health and Production Investigations)	1,628	463
Revenue Fund—Regional Pastoral Research Station (Animal Health and Production Investigations)	6,101	3,500
General Donations—Building Research Section	26	..
Revenue Fund—Infertility, F. D. McMaster Field Station (Animal Health and Production Investigations)	4,105	1,427
Dairy Revenue Fund—F. D. McMaster Field Station (Animal Health and Production Investigations)	369	369
Revenue Fund—Toxaemic Jaundice Investigations, Barooga, New South Wales (Animal Health and Production Investigations)	1,528	479
Revenue Fund—Nutrition Laboratory (Biochemistry and General Nutrition Investigations)	4,077	..
Revenue Fund—Plant Industry Investigations	6,950	..
Revenue Fund—Entomological Investigations	1,089	..
Revenue Fund—Griffith Research Station (Citricultural Investigations)	1,705	1,442
Revenue Fund—Merbein Research Station (Viticultural Investigations)	11,475	1,466
Revenue Fund—Division of Food Preservation and Transport	241	158
Revenue Fund—Egg Investigations, Egg Producers' Council (Division of Food Preservation and Transport)	277	59
Revenue Fund—Mining and Metallurgy	14	..
Revenue Fund—Ore-dressing Investigations	1,017	..
Revenue Fund—Fisheries Investigations	326	..
Revenue Fund—Oyster Investigations	230	150
Revenue Fund—Physics	988	..
Revenue Fund—National Standards Laboratory	35	..
Revenue Fund—Metrology	1,971	..
Revenue Fund—Dairy Investigations	23	..
Revenue Fund—Electrotechnology	252	..
Revenue Fund — Industrial Chemistry	524	..
Revenue Fund—Radiophysics	46	..
Revenue Fund—Merbein Research Station—Production of Pyrethrum	185	..
Revenue Fund—Information Service	77	..
	221,245	145,310

P. Includes £235 on account of 1947-48 expenditure.
Q. Includes £16 on account of 1947-48 expenditure.

3. WOOL RESEARCH TRUST ACCOUNT.

A credit balance of £564,122 was brought forward from 1947-48 in the Wool Research Trust Account. A further £317,050 was received during 1948-49 from the Department of Commerce and Agriculture. Expenditure during 1948-49 was as follows:—

	£	£	£
Division of Animal Health and Production—			
Sheep Physiology Investigations—Parkville	2,779		
Sheep Physiology Investigations—Tooradin	1,616		
Chemical Pathology Investigations—Parkville	394		
Toxaemic Jaundice Investigations—Barooga	1,031		
Toxaemic Jaundice Investigations—Cobram	3,410		
McMaster Laboratory—			
Parasitology Investigations ..	3,547		
Parasite Physiology and Toxicology	634		
Dipping and External Parasites ..	765		
Biochemical Investigations ..	2,485		
Physiology of Reproduction ..	3,117		
Prospect—Sheep Biology Laboratory	7		
Prospect—Sheep Biology Laboratory—Fleece Analysis	9,413		
Sheep Biology Laboratory—Wool Biology	4,911		
Sheep Biology Laboratory—Strain Trial Investigations	9,824		
Co-operative Investigations—Queensland. Wool Production ..	366		
Armidale Regional Laboratory—			
Parasitology Field Investigations	23,971		
Survey of Wool Production ..	1,525		
National Field Station, "Gilruth Plains"—			
Capital	681		
Animal Breeding	2,817		
Agrostology	320		
Conference of Sheep Research and Wool Research Officers	95		
McMaster Biochemistry Laboratory—Building Alterations	35		
Clover Infertility Investigations ..	17		
		73,760	
Division of Plant Industry—			
Agrostology Investigations ..	27,961		
Mineral Deficiency Studies ..	1,438		
		29,399	
Division of Entomology—			
Cockchafer Grub Investigations ..	211		
		211	
Division of Biochemistry and General Nutrition—			
Biochemical and Nutritional Investigations	14,539		
		14,539	
Wool Textile Research	36,832		
		36,832	
Miscellaneous—			
Overseas Studentships	4,221		
		4,221	
			158,962
Grants from Wool Research Trust Account to Institutions undertaking extra-mural co-operative wool research—			
University of Melbourne—Survey of Wool Industry in Western District	1,250		
University of Western Australia—Investigations at Institute of Agriculture, Western Australia	1,700		
Department of Agriculture, Western Australia—Sheep Infertility Investigations	1,250		
Roseworthy Agricultural College—Progeny Testing and Allied Studies	1,910		
Sydney Technical College—Wool Clip Analysis	1,500		
University of Sydney—Animal Physiology and Sheep Infertility Investigations	1,650		
Department of Agriculture and Stock, Queensland — Progeny Testing and Fertility Investigations	1,300		
Carried forward	10,560		
Brought forward	10,560	..	158,962
Gordon Institute of Technology, Geelong—Wool Textile Investigations	1,500		
Wool Industries Research Association, Leeds, U.K.—Wool Textile Investigations	1,254		
		13,314	
Grants from Wool Research Trust Account to Institutions undertaking research in Agricultural Economics relating to wool production—			
University of Western Australia ..	1,000		
Roseworthy Agricultural College ..	1,100		
University of Melbourne ..	563		
University of Adelaide	318		
University of Tasmania	700		
Department of Commerce and Agriculture—			
Division of Agricultural Economics	10,061		
Dr. H. W. Bennetts	251		
		13,993	
Miscellaneous administrative expenses	16		
		16	
			27,323
			186,285

4. STAFF.

The following is a list of the staff of the Organization as at 30th June, 1949. The list does not include clerical staff, typists, laboratory assistants, and miscellaneous workers.

(a) *Head Office Staff.*

(Head-quarters: 314 Albert-street, East Melbourne.)

Chairman—I. Clunies Ross, D.V.Sc.
Chief Executive Officer—F. W. G. White, M.Sc., Ph.D.
Executive Officer—S. H. Bastow, D.S.O., B.Sc., Ph.D.
Secretary—G. A. Cook, M.C., M.Sc., B.M.E.
Assistant Secretary—F. G. Nicholls, M.Sc.
Assistant Secretary—H. C. Forster, M.Agr.Sc., Ph.D.
Assistant Secretary—G. B. Gresford, B.Sc.
Assistant Secretary (Finance and Supplies)—M. G. Grace, A.I.C.A.
Miss J. Dunstone, B.Sc., Dip.Ed.
Architect—W. R. Ferguson, B.E.
Electrical and Mechanical Engineer—R. N. Morse, B.Sc., B.E.
Mechanical Engineer—F. G. Hogg, B.E.
Electrical Engineer—A. McLean, B.E.E.

Editorial—
Editor—N. S. Noble, D.Sc.Agr., M.S., D.I.C.
Research Officer—Miss L. F. Plunkett, B.Sc.
Research Officer—Miss M. Walkom, B.A.

Library—
Chief Librarian—Miss E. Archer, M.Sc.
Librarian—Miss A. L. Kent.
Librarian—Miss F. V. Murray, M.Sc.
Assistant Librarian—Miss J. A. Conochie, B.Sc.
Assistant Librarian—Miss E. E. Scurrah.
Assistant Librarian—Miss J. M. Flaherty, B.A.

Accounts, Stores—
Accountant—D. J. Bryant, A.F.I.A.

Orders and Transport—
J. M. Derum.

Staff—
Staff and Industrial Officer—H. E. Waterman, A.F.I.A.
R. D. Elder.

Records—
P. Knuckey.

Liaison Overseas—
London—
J. E. Cummins, B.Sc., M.S.
A. B. Hackwell, B.Agr.Sc.
Washington—
T. C. Bell, B.Agr.Sc.

Information Service—

Administration—

Officer-in-Charge—C. M. Gray, O.B.E., M.Sc.
Technical Secretary—F. A. Priest, A.S.A.S.M.
Technical Records and Processing—Mrs. J. M. E. Travers, B.Sc.

Information Section—

Senior Research Officer—D. T. C. Gillespie, M.Sc. (seconded).
Research Officer—G. J. Wylie, B.A., B.Sc.
Research Officer—J. F. H. Wright, B.Sc.
Research Officer—Miss J. McL. Baldwin, B.Sc., Dip.Ed.
Research Officer—Miss S. M. Andrews, B.Sc.
Research Officer—H. E. Booth, A.S.T.C.
Overseas Information—Miss I. H. Robertson, M.Sc., D.A.C.

Translation Section—

Senior Translator—A. L. Gunn.
Translator—E. Feigl, Ph.D.
Translator—E. W. Selman-Towt.
Translator—Mrs. M. Slade.
Translator—Miss P. A. Gibson, B.A.
Translator—C. W. Wouters, D.es L.

Cine-photographic Section—

Research Officer—S. T. Evans, B.Sc.
Photographer—L. E. Cuffley.

Commonwealth Agricultural Bureaux—

Liaison Officer for Australia—A. B. Cashmore, M.Sc.

Sydney Office—

Research Officer—A. M. Andrews, B.Sc.

(b) *Secretaries of State Committees.*

New South Wales—

A. M. Andrews, B.Sc., Phillip House, 119 Phillip-street, Sydney.

Victoria—

F. G. Nicholls, M.Sc., 314 Albert-street, East Melbourne.

Queensland—

Miss H. F. Todd, 113 Eagle-street, Brisbane.

South Australia—

J. Ward Walters, Division of Biochemistry and General Nutrition, University of Adelaide.

Western Australia—

R. P. Roberts, M.Sc.(Agric.), Department of Agriculture, Perth, W.A.

Tasmania—

F. J. Carter, c/o Premier's Office, Hobart.

(c) *Division of Plant Industry.*

(Head-quarters: Canberra, A.C.T.)

At Canberra—

Administration—

Chief—B. T. Dickson, B.A., Ph.D.
Technical Secretary—W. Ives, M.Ec., A.I.C.A.
Technical Officer (photographer)—J. B. Pomeroy.
Librarian (half-time)—Miss J. Humphreys, B.A., Dip.Ed.
Assistant Librarian (half-time)—Miss M. Campbell-Smith.
Senior Clerical Officer (half-time)—K. J. Prowse.
Accountant (half-time)—D. W. Banyard.

Host-Pathogen Studies—

Principal Research Officer—H. R. Angell, O.B.E., Ph.D.

Microbiology—

Acting Senior Research Officer—D. O. Norris, D.Sc. (Agric.).
Senior Research Officer—W. V. Ludbrook, M.S., B.Agr.Sc., Ph.D.
Research Officer—J. H. E. Mackay, B.Sc.Agr.
Research Officer—Miss M. Mills, B.Sc.
Research Officer—Miss K. Helms, B.Sc.
Junior Technical Officer—J. Brockwell, D.D.A.

Plant Introduction—

Senior Research Officer—W. Hartley, B.A., Dip.Agr.
Research Officer—C. A. Neal-Smith, B.Agr.Sc., R.D.A.

Horticultural Investigations—

Principal Research Officer—C. Barnard, D.Sc.

Medicinal and Drug Plant Investigations—

Senior Research Officer—K. L. Hills, M.Agr.Sc.
Research Officer—Miss C. Rodwell, M.Sc.
Technical Officer—Miss S. I. Eldridge, A.S.T.C.

Plant Physiology—

Senior Research Officer—R. F. Williams (seconded to Griffith).
Research Officer—J. Calvert, D.Sc.

Herbarium—

Research Officer—Miss N. T. Burbidge, M.Sc.

Agrostology—

Senior Principal Research Officer—J. G. Davies, B.Sc., Ph.D.
Principal Research Officer—C. S. Christian, M.Sc.
Principal Research Officer—C. M. Donald, M.Agr.Sc.
Senior Research Officer—W. D. Andrew, M.Agr.Sc.
Research Officer—W. M. Willoughby, B.Sc.Agr.
Research Officer—K. D. McLachlan, B.Sc.Agr.
Research Officer—E. F. Biddiscombe, B.Sc. (Agric.).
Research Officer—R. A. Perry, B.Sc.
Technical Officer—R. E. Herrington, Q.D.H.
Technical Officer—G. R. Thomas, Q.D.A.H.
Technical Officer—R. G. Fawcett, R.D.A.
Technical Assistant—A. Axelsen, Q.D.A.H.

Agrostology, Pasture Ecology—

Research Officer—C. W. E. Moore, B.Agr.Sc.

Agrostology, Weeds Investigations—

Senior Research Officer—R. M. Moore, B.Sc.Agr.
Technical Officer—C. S. McKay, Dip.Agr.D.
Technical Officer—R. T. Milligan, Dip.Agr.D.
Technical Officer—J. A. Robertson, Q.D.D.M.

Agrostology, Mineral Deficiency Studies—

Research Officer—A. J. Anderson, B.Sc.(Agric.).
Research Officer—D. Spencer, B.Sc.
Technical Officer—D. Moye, H.D.A.

Agrostology, Weeds Physiology—

Senior Research Officer—C. G. Greenham, M.Sc.
Research Officer—P. Goldacre, B.Sc.

Agrostology, Pasture Chemistry—

Senior Research Officer—C. H. Williams, M.Sc.
Technical Officer—F. K. Mayer, Q.D.A.

Tobacco Investigations—

Senior Research Officer—A. V. Hill, M.Agr.Sc.
Research Officer—R. Johanson, M.Sc.
Technical Officer—G. P. Kelenyi, Dip.Agr.D.

Vegetable Investigations—

Senior Research Officer—E. M. Hutton, M.Sc., B.Agr.Sc.
Research Officer—D. C. Wark, M.Agr.Sc.
Research Officer—R. D. Brock, B.Agr.Sc.
Technical Officer—A. R. Peak, H.D.A.
Technical Officer—R. R. Rochford.
Technical Officer—J. W. Peak.

Dickson Experiment Station, Canberra, Australian Capital Territory—

Manager—L. Sharp, Dip.Agr.D.

At Queensland University, Brisbane, Queensland—

Senior Research Officer (agrostology)—T. B. Paltridge, B.Sc.
Senior Research Officer (plant introduction)—J. F. Miles, B. Agr.Sc.
Research Officer (pasture chemistry)—E. H. Kipps, B.Sc.
Research Officer (native plants investigations)—L. J. Webb, B.Sc.
Research Officer (agrostology)—Miss H. Barford, B.Sc.
Clerical Officer—K. J. Fogarty.

At Cooper Laboratory, Queensland Agricultural High School and College, Lawes—

Research Officer (agrostology)—N. H. Shaw, B.Agr.Sc.
Research Officer (plant introduction)—S. G. Gray, B.Sc.Agr.
Research Officer (agrostology)—W. J. Bisset, B.Agr.Sc.
Technical Officer (plant introduction)—K. B. Anderssen, Q.D.A.
Technical Officer (plant introduction)—W. G. Robertson, Q.D.A. (on study leave).
Technical Officer (agrostology)—W. J. Wyndham, Q.D.D.H.
Technical Officer (agrostology)—R. Milford, Q.D.A. (on study leave).
Technical Officer (agrostology)—G. J. Downing, Q.D.A.H.
Technical Officer (agrostology)—T. W. Elich, Dip.Col.Ag. (Holland).
Technical Officer (agrostology)—R. H. Macarthur, Q.D.A.H.
Technical Officer (agrostology)— W. H. J. Pieters, Dip.Col.Ag. (Holland).
Technical Officer (agrostology)—M. J. Hibberd, Q.D.A.H.
Technical Officer (agrostology)—H. Kiers, Dip. Col.Ag. (Holland).

At Gilruth Plains, Queensland—

Technical Officer (agrostology)—K. C. Baker, Q.D.A.

At Stanthorpe, Queensland—

Senior Research Officer (horticultural investigations)—L. A. Thomas, M.Sc.
Research Officer (horticultural investigations)—R. C. Colbran, B.Agr.Sc.

At Regional Pastoral Laboratory, Deniliquin, New South Wales—

Senior Research Officer (agrostology)—R. W. Prunster, B.Sc.(Agric).
Senior Research Officer (agrostology)—A. L. Tisdall, M.Agr.Sc.
Research Officer (agrostology)—O. B. Williams, B.Agr.Sc.
Technical Officer (agrostology)—K. R. Brown, Dip.Agr.D.
Technical Officer (agrostology)—F. Arndt, Q.D.A.
Clerical Officer—S. J. Cossar.

At Falkiner Memorial Field Station, Deniliquin, New South Wales—

Station Manager—G. A. Vasey.

At the University of Western Australia, Perth, Western Australia—

Senior Research Officer (agrostology)—R. C. Rossiter, B.Sc.(Agric.).
Research Officer (plant introduction)—E. T. Bailey, B.Sc.
Technical Officer (agrostology)—R. J. Pack, Q.D.A.
Technical Officer (plant introduction)—N. B. Gayfer, Dip.Agr.D.
Technical Officer (agrostology)—J. Beresford, Dip.Agr.D.

At Kojonup, Western Australia—

Research Officer—H. L. Pennington, B.Sc. (Agric.).
Station Manager—J. Tudor.

At Regional Pastoral Laboratory, Armidale, New South Wales—

Senior Research Officer (agrostology)—R. Roe, B.Sc.(Agric.).
Research Officer (agrostology)—E. J. Hilder, B.Sc.(Agric.).
Technical Officer (agrostology)—A. J. Callander, H.D.A.
Junior Technical Officer (agrostology)—E. G. Harrison, Dip.Agr.D.

At Hobart, Tasmania—

Senior Research Officer (horticultural investigations)—D. Martin, B.Sc.

At Kimberley Research Station, Western Australia—

Technical Officer (agrostology)—E. C. B. Langfield.

At Katherine Experimental Farm, Northern Territory—

Research Officer—W. Arndt, B.Agr.Sc.
Technical Officer—L. J. Phillips, Q.D.D.M.
Technical Officer—G. Kent, Q.D.A.
Farm Manager—F. Kent, H.D.A.
Clerical Officer—A. T. C. Watson.

At State Experiment Farm, Trangie, New South Wales—

Technical Officer (agrostology)—R. J. Hutchings, Dip.Agr.D.

At Waite Agricultural Research Institute, Adelaide, South Australia—

Principal Research Officer (physiology)—L. A. T. Ballard, Ph.D., M.Ag.Sc.
Research Officer (apricot gummosis investigations)—Miss J. Grace, B.Sc.Agr.

Northern Australia Regional Survey—

Supply and Transport Officer—H. J. Mason.

At Ayr, North Queensland—

Research Officer (tobacco)—W. J. Lovett, B.Agr.Sc.
Research Officer (tobacco)—T. G. Haney, B.Sc.Agr.
Research Officer (agrostology)—F. H. Kleinschmidt, B.Agr.Sc.
Technical Officer (tobacco)—D. W. L. Simmons, D.D.A.
Technical Officer (tobacco)—J. D. Fitzsimon, Q.D.A., Q.D.H.

At Griffith, New South Wales—

Research Officer (weeds investigations)—L. F. Myers, B.Agr.Sc.

(d) *Division of Entomology.*

(Head-quarters: Canberra, A.C.T.)

At Canberra—

Administration—

Chief—A. J. Nicholson, D.Sc.
Technical Secretary—I. F. B. Common, M.A., B.Agr.Sc.
Librarian (half-time)—Miss J. Humphreys, B.A., Dip.Ed.
Senior Clerical Officer (half-time)—K. J. Prowse.
Accountant (half-time)—D. W. Banyard.
Illustrator—L. A. Marshall.

Biological Control—

Senior Research Officer—F. Wilson.
Research Officer—E. F. Riek, M.Sc.
Technical Officer—G. R. Wearne.

Museum—

Research Officer—T. G. Campbell.
Research Officer—S. J. Paramonov, D.Sc.

Physiology and Toxicology—

Senior Research Officer—D. F. Waterhouse, M.Sc. A.A.C.I.
Senior Research Officer—M. F. Day, B.Sc., Ph.D.
Senior Research Officer—D. Gilmour, M.Sc.
Research Officer—R. H. Hackman, M.Sc. Ph.D. (seconded from Division of Industrial Chemistry).
Research Officer—R. W. Kerr, B.Sc.
Research Officer—R. F. Powning, A.S.T.C.

Technical Officer—J. H. Calaby.
Technical Officer—L. G. Webber.
Locust and Pasture Pests—
Senior Research Officer—K. H. L. Key, D.Sc.
Research Officer—P. B. Carne, B.Agr.Sc.
Virus Vector Investigations—
Senior Research Officer—G. A. Helson, M.Sc.
Technical Officer—N. E. Grylls.
Termite Investigations—
Senior Research Officer—F. J. Gay, B.Sc., D.I.C.
Technical Officer—A. Wetherly.
Sheep Blowfly Investigations—
Senior Research Officer—K. R. Norris, M.Sc. (abroad).
Meat Ant Investigations—
Research Officer—T. Greaves.
Population Dynamics—
Chief of Division—A. J. Nicholson, D.Sc.
Technical Officer—A. T. Mills.
Technical Officer—S. Dee.

At Yeerongpilly, Queensland—
Cattle Tick Investigations—
Senior Research Officer—L. F. Hitchcock, M.Sc.
Research Officer—W. J. Roulston, B.Sc.
Research Officer—G. J. Snowball, B.Sc.
Technical Officer—R. A. J. Meyers, Q.D.A.H., Q.D.D.
Technical Officer—J. T. Wilson, Q.D.A.
Technical Officer—B. F. Healy, Q.D.A.

In Western Australia—
Earthmite Investigations—
Research Officer—M. M. H. Wallace, B.Sc. (abroad).
Technical Officer—J. A. Mahon, Dip.D.Sci.

At Bright, Victoria—
St. John's Wort Investigations—
Research Officer—L. R. Clark, M.Sc.
Research Officer—Mrs. N. Clark, B.Sc.Agr.
Technical Officer—E. R. Pearce, Dip.Agr.

At Trangie, New South Wales—
Locust Investigations—
Technical Officer—L. J. Chinnick, Dip.Agr.

(*e*) *Division of Animal Health and Production.*

(Head-quarters: Cr. Flemington-road and Park-street, Parkville, Melbourne.)

At Divisional Head-quarters, Melbourne—
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Divisional Secretary—A. J. Vasey, B.Agr.Sc.
Clerk—J. J. Foley.

At Animal Health Research Laboratory, Melbourne—
Officer-in-Charge—A. W. Turner, O.B.E., D.Sc., D.V.Sc.
Principal Research Officer (bacteriology)—T. S. Gregory, B.V.Sc., Dip.Bact.
Principal Research Officer (pathology, bacteriology, dairy cattle)—D. Murnane, B.V.Sc.
Senior Research Officer (serological investigations)—A. D. Campbell, L.V.Sc.
Senior Research Officer (physiology)—R. H. Watson, D.Sc.Agr.
Senior Research Officer (immuno-chemistry)—A. T. Dann, M.Sc.
Senior Research Officer (chemical pathology and bacteriology)—A. T. Dick, M.Sc.
Research Officer (bacteriology, dairy cattle)—E. Munch-Petersen, M.Sc., B.A., M.I.F.
Research Officer (poultry breeding investigations)—F. Skaller, B.Agr.Sc.
Research Officer (bacteriology, anaerobic infections)—A. W. Rodwell, M.Sc. (abroad).
Research Officer (chemical pathology and analytical chemistry)—J. B. Bingley, D.A.C.
Research Officer—Miss C. E. Eales, B.Sc.
Research Officer—Miss M. J. Monsbrough, B.Sc.
Research Officer—H. G. Turner, B.Agr.Sc. (abroad).
Research Officer—G. Alexander, B.Agr.Sc.
Research Officer—G. W. Grigg, B.Sc. (part-time).
Technical Officer—H. M. Radford, B.Sc.
Technical Officer—Miss V. E. Hodgetts, B.Sc.
Technical Officer—E. A. Parrish.
Technical Officer—M. W. Mules.
Technical Officer—E. Wold.
Technical Officer—A. E. Wright.
Technical Officer—J. J. Spencer.
Technical Officer—R. A. Fookes.
Technical Officer—N. E. Southern.
Technical Officer (animal husbandry)—L. C. Gamble.
Technical Officer (animal husbandry)—D. H. Lawrence.
Technical Officer (animal husbandry)—W. J. Lloyd.
Librarian—Miss F. V. Murray, M.Sc. (part-time).

At F. D. McMaster Animal Health Laboratory, Sydney, New South Wales—
Officer-in-Charge—D. A. Gill, M.R.C.V.S., D.V.S.M.
Senior Research Officer (parasitology)—H. McL. Gordon, B.V.Sc.
Senior Research Officer (biochemistry)—M. C. Franklin, M.Sc., Ph.D.
Senior Research Officer (parasitology)—W. P. Rogers, M.Sc., Ph.D.
Senior Research Officer (bacteriology)—D. F. Stewart, B.V.Sc., Dip.Bact.
Research Officer (biochemistry)—C. R. Austin, M.Sc., B.V.Sc.
Research Officer (physiology)—W. K. Whitten, B.V.Sc.
Research Officer (biochemistry)—R. L. Reid, B.Sc.Agr., Ph.D.
Research Officer (parasitology)—B. A. Forsyth, B.V.Sc.
Research Officer (ectoparasites)—Miss T. M. Scott, B.Sc.
Research Officer (parasitology)—Miss P. M. Sambell, B.A.
Research Officer (parasitology)—Miss H. B. Esserman, B.Sc.
Technical Officer—H. A. Offord.
Technical Officer—F. J. Hamilton.
Technical Officer—H. V. Whitlock.
Technical Officer—P. B. Sutton.
Clerk—H. H. Wilson.
Librarian—Miss A. G. Culey, M.Sc.

At Wool Biology Laboratory, Sydney, New South Wales—
Officer-in-Charge (wool biology)—H. B. Carter, B.V.Sc.
Research Officer (wool biology)—Miss M. Hardy, M.Sc. (abroad).
Research Officer (wool biology)—K. Ferguson, B.V.Sc. (abroad).
Research Officer (wool biology)—Miss P. Davidson, B.Sc.
Technical Officer—D. L. Hall.
Technical Officer—W. H. Clarke.

At Fleece Analysis Laboratory, Villawood, New South Wales—
Officer-in-Charge (wool metrology)—N. F. Roberts, M.Sc.
Research Officer (wool metrology)—L. T. Wilson, B.Sc., A.A.C.I.
Technical Officer—Miss L. Folley.

At Regional Pastoral Laboratory, Armidale, New South Wales—
Officer-in-Charge (parasitology, field studies)—I. L. Johnstone, B.V.Sc.
Research Officer (animal husbandry)—J. F. Barrett, B.V.Sc.

Research Officer (parasitology)—W. H. Southcott, B.V.Sc.
Technical Officer (overseer)—V. D. Prentice, O.B.E.
Technical Officer—R. S. Norton.
Technical Officer—A. Stephenson.

At F. D. McMaster Field Station, Badgery's Creek, New South Wales—
Officer-in-Charge (animal genetics)—R. B. Kelley, D.V.Sc.
Senior Research Officer (beef cattle production)—W. A. Beattie, B.A., LL.B.
Senior Research Officer (wool production)—J. H. Riches, B.Sc.(Agric.), Ph.D.
Research Officer (sheep breeding)—R. H. Hayman, B.Agr.Sc.
Research Officer (sheep breeding)—J. A. Morris, B.Sc.Agr.
Technical Officer—J. R. Holloway.

At Veterinary Parasitology Laboratory, Yeerongpilly, Queensland—
Officer-in-Charge (parasitology)—F. H. S. Roberts, D.Sc.
Research Officer (parasitology)—P. H. Durie, B.Sc.
Research Officer (entomology, pathology)—R. S. Riek, B.V.Sc.

At Food Preservation Research Laboratory, Cannon Hill, Queensland—
Research Officer (carcass appraisal)—N. T. M. Yeates, B.Sc.Agr., Ph.D.

At National Field Station, "Gilruth Plains", Cunnamulla, Queensland—
Officer-in-Charge (sheep breeding)—J. F. Kennedy, M.Agr.Sc.
Technical Officer (overseer)—R. N. Fogg.
Technical Officer—P. H. G. Sheaffe.
Technical Officer—B. G. Jackson.

At Western Australian Department of Agriculture, Animal Health and Nutrition Laboratory, Nedlands, Western Australia—
Research Officer (biochemistry)—A. B. Beck, M.Sc.

(*f*) *Division of Biochemistry and General Nutrition.*

(Head-quarters: At University of Adelaide.)

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Divisional Secretary—J. Ward Walters.
Principal Research Officer—A. W. Peirce, D.Sc.
Senior Research Officer—E. W. Lines, B.Sc.
Senior Research Officer—H. J. Lee, B.Sc.
Senior Research Officer—D. S. Riceman, M.Sc., B.Agr.Sc.
Senior Research Officer—F. V. Gray, M.Sc.
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Research Officer—I. G. Jarrett, M.Sc.
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Research Officer—Miss S. H. Allen, B.Sc.
Research Officer—Miss P. Macbeth, B.Sc.
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Research Officer—B. J. Potter, B.Sc.
Research Officer—J. K. Powrie, B.Sc.(Agric.).
Research Officer—R. M. Smith, B.Sc.
Research Officer—R. A. Weller, B.Sc.
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Technical Officer—J. O. Wilson.
Technical Officer—C. E. Sleigh.
Technical Officer—R. F. Trowbridge.
Technical Officer—D. F. Graham.
Technical Officer—V. A. Stephen.
Technical Officer—R. Underdown.
Farm Manager—R. H. Jones, R.D.A.
Librarian—Miss I. Sanders, B.A.

(*g*) *Division of Soils.*

(Head-quarters: Waite Agricultural Research Institute, Adelaide.)

Chief of Division—J. K. Taylor, B.A., M.Sc., B.Sc.Agr.
Principal Research Officer—C. G. Stephens, M.Sc.
Principal Research Officer—T. J. Marshall, M.Ag.Sc., Ph.D.
Senior Chemist—C. S. Piper, D.Sc.
Senior Research Officer—G. D. Hubble, B.Ag.Sc.
Senior Research Officer—R. Smith, B.Ag.Sc.
Research Officer—B. E. Butler, B.Agr.Sc.
Research Officer—R. G. Downes, M.Agr.Sc.
Research Officer—A. C. Oertel, M.Sc., A.A.C.I., A.Inst.P.
Research Officer—A. E. Martin, B.Sc., F.R.I.C.
Research Officer—A. G. Turton, B.Sc.
Research Officer—G. D. Aitchison, B.E.
Research Officer—K. D. Nicolls, B.Ag.Sc., B.Sc.
Research Officer—E. J. Johnston, B.Sc.Agr.
Research Officer—J. T. Hutton, B.Sc., A.S.A.S.M.
Research Officer—R. Brewer, B.Sc.
Research Officer—K. H. Northcote, B.Ag.Sc.
Research Officer—G. Blackburn, B.Agr.Sc.
Research Officer—G. A. Stewart, B.Ag.Sc.
Research Officer—H. C. T. Stace, B.Sc.
Research Officer—B. M. Tucker, B.Sc.
Research Officer—J. R. Harris, B.Sc.
Research Officer—T. Langford-Smith, M.Sc. (seconded).
Research Officer—K. Norrish, M.Sc.
Research Officer—G. B. Stirk, B.Sc.
Research Officer—J. P. Quirk, B.Sc.Agr.
Research Officer—Miss M. P. Thomas, B.Sc.
Research Officer—R. S. Beckwith, B.Sc.
Research Officer—M. Raupach, B.Sc.
Research Officer—E. W. Boehm, B.Sc.(Agric.).
Research Officer—C. G. Gurr, B.Sc.
Research Officer—J. R. Sleeman, B.Ag.Sc.
Research Officer—W. I. Nankivell, B.Ag.Sc.
Research Officer—G. M. Dimmock, B.Sc.
Technical Officer—A. D. Haldane, B.Sc.
Technical Officer—C. H. Thompson.
Technical Officer—L. W. Pym.
Technical Officer—Miss S. E. Correll.
Technical Officer—I. F. Reynolds.
Technical Officer—A. R. P. Clarke.
Technical Officer—A. W. Palm.
Draughtsman—P. D. Hooper.
Draughtsman—R. B. Ewers.
Rubber Investigations—R. E. Shapter, A.A.C.I.

(*h*) *Irrigation Settlement Problems.*

At Irrigation Research Station, Griffith—
Officer-in-Charge—E. S. West, B.Sc., M.S.
Senior Research Officer (chemist)—N. G. Cassidy, M.Sc.
Senior Research Officer (plant physiology)—R. F. Williams, M.Sc.
Research Officer (irrigation)—O. Perkman, B.Sc.Agr.
Research Officer (drainage)—V. J. Wagner, B.Agr.Sc.
Research Officer (vegetable agronomy)—K. Spencer, B.Sc.Agr.
Research Officer (weeds)—L. F. Myers, B.Agr.Sc.
Research Officer (horticulture)—H. J. Frith, B.Sc.Agr.
Research Officer (plant physiology)—C. T. Gates, B.Sc.Agr.
Research Officer—E. L. Greacen, B.Sc.Agr., Ph.D.
Senior Technical Officer (orchard superintendent)—B. H. Martin, H.D.A.
Technical Officer (photography)—A. N. Huon.
Technical Officer (chemistry)—Miss J. Connor.
Librarian—Miss M. Russell.

Seconded to New South Wales Department of Agriculture—
Senior Research Officer—R. R. Pennefather, B.Agr.Sc.
Senior Research Officer—D. V. Walters, M.Agr.Sc.
Research Officer—A. F. Gurnett Smith, B.Agr.Sc., Q.D.D.
Research Officer—Mrs. Joan Tully, B.Sc., Ph.D.

At Commonwealth Research Station, Merbein—
Officer-in-Charge—A. V. Lyon, M.Agr.Sc.
Principal Research Officer—E. C. Orton, B.Sc.
Research Officer—J. G. Baldwin, B.Agr.Sc., B.Sc.
Research Officer—G. V. F. Clewett, B.E.
Research Officer—W. J. Webster, B.Sc.
Research Officer—A. J. Antcliff, B.Sc.
Research Officer—M. R. Sauer, B.Agr.Sc.
Research Officer—S. F. Bridley, B.Agr.Sc.
Research Officer—R. C. Woodham, B.Agr.Sc.
Research Officer—D. M. Alexander, B.Sc.
Technical Officer—J. E. Giles.
District Officer (Nyah-Woorinen)—R. C. Polkinghorne (part-time).
District Officer (Wakool)—H. Jackson (part-time).
District Officer (Renmark)—J. V. Seekamp (part-time).

(*i*) *Division of Forest Products.*

(Head-quarters: 69 Yarra Bank-road, South Melbourne.)

Administration—
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Assistant to Chief—C. S. Elliot, B.Sc.
Assistant to Chief—H. E. Dadswell, D.Sc.
Librarian—Miss M. I. Hulme.
Assistant to Librarian—Miss A. Forbes.
Clerk—J. Bourne.
Clerk—A. D. Rampling.
Records Clerk—G. K. Johnson.
Senior Technical Officer—L. Santer, Dip.Eng.

Wood Structure Section—
Senior Principal Research Officer-in-Charge—H. E. Dadswell, D.Sc.
Senior Research Officer—Miss M. M. Chattaway, B.A., B.Sc., D.Phil.
Senior Research Officer—H. D. Ingle, B.For.Sc.
Research Officer—G. L. Amos, M.Sc.
Research Officer—I. J. W. Bissett, B.Sc.
Research Officer—A. B. Wardrop, M.Sc., Ph.D.
Technical Officer—Miss Florence V. Griffin.
Technical Officer—W. McKenzie, B.Sc.

Photography—
Technical Officer—Miss Audrey M. Lightfoot.
Technical Officer—W. G. Hastie.

Wood Chemistry Section—
Senior Principal Research Officer-in-Charge—W. E. Cohen, D.Sc. (overseas).
Senior Research Officer—D. E. Bland, M.Sc. (Acting-in-Charge).
Research Officer—Miss C. M. Emery, B.Sc.
Research Officer—D. H. Foster, M.Sc.
Research Officer—C. M. Stewart, B.Sc.
Research Officer—A. J. Watson, A.M.T.C.
Technical Officer—A. G. Charles.
Technical Officer—W. E. Hillis, B.Sc., A.G.Inst.Tech.
Technical Officer—G. Ho, B.Agr.Sc.
Technical Officer—Miss G. M. Schwerin.

Timber Physics Section—
Senior Research Officer-in-Charge—R. S. T. Kingston, B.Sc., B.E.
Research Officer—L. N. Clarke, B.Eng.Sc.
Research Officer—Miss K. E. Kelsey, B.Sc.
Technical Officer—I. G. Scott, F.M.T.C.
Technical Officer—A. Ack Hing, A.S.M.B.
Technical Officer—N. C. Edwards, A.S.M.B.
Technical Officer—L. D. Armstrong.

Timber Mechanics Section—
Principal Research Officer-in-Charge—K. L. Cooper, M.A., B.Sc.
Research Officer—J. D. Boyd, M.C.E.
Research Officer—C. E. Dixon, M.Sc.
Research Officer—N. H. Kloot, B.Sc.
Research Officer—R. G. Pearson, B.C.E.
Technical Officer—J. J. Mack.

Timber Seasoning Section—
Senior Research Officer-in-Charge—G. W. Wright, B.E.
Research Officer—E. L. Ellwood, B.Sc. (For.).
Research Officer—J. W. Gottstein, B.Sc.
Research Officer—C. V. Lansell, B.Eng.Sc.
Senior Technical Officer—F. A. Dale, Dip.Mech.Eng.
Technical Officer—L. J. Brennan.
Technical Officer—G. S. Campbell.
Technical Officer—H. D. Roberts.

Timber Preservation Section—
Senior Research Officer-in-Charge—N. Tamblyn, M.Sc.(Agric.).
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Research Officer—G. N. Christensen, B.Sc.
Research Officer—E. W. B. Da Costa, M.Agr.Sc.
Research Officer—G. W. Tack, B.Agr.Sc.
Technical Officer—J. Beesley, B.Sc.(For.), Dip. For.
Technical Officer—R. E. Kneale.
Technical Officer—Miss N. Robinson.
Technical Officer—A. Rosel.
Technical Officer—T. A. McLelland, B.Sc., Dip. App.Chem.
Technical Officer—L. A. Bennett (part-time).

Veneer and Gluing Section—
Senior Research Officer-in-Charge—A. Gordon, B.Sc.
Research Officer—H. G. Higgins, B.Sc.
Research Officer—K. F. Plomley, B.Sc.Agr.
Technical Officer—Miss J. U. Barrie.
Technical Officer—J. F. Hayes, B.Sc.
Technical Officer—C. Koch, B.S.(For.).

Utilization Section—
Principal Research Officer-in-Charge—R. F. Turnbull, B.E.
Research Officer—A. E. Head, B.Sc.
Research Officer—C. H. Hebblethwaite, Dip.For.
Technical Officer—S. J. Colwell, Dip.Mech.Eng.
Technical Officer—D. M. Cullity, B.Sc.
Technical Officer—R. G. Skewes, Dip.Mech.Eng., Dip.E.E., A.M.I.E.Aust.

Maintenance Section—
Senior Technical Officer—S. G. McNeil.

(*j*) *Division of Food Preservation and Transport.*

(Head-quarters: State Abattoir, Homebush Bay; Postal Address: Private Bag, Homebush P.O., N.S.W.)

Administration and General—
Chief—J. R. Vickery, M.Sc., Ph.D.
Technical Secretary—R. B. Withers, M.Sc., Dip.Ed.
Librarian—Miss B. Johnston, B.Sc.
Maintenance Engineer—T. L. Swan.

Physics Section—
Principal Research Officer—E. W. Hicks, B.A., B.Sc.
Research Officer—M. C. Taylor, M.Sc.
Research Officer—G. M. Rostos, Dipl.Ing.
Technical Officer—M. B. Smith, A.S.A.S.M.
Technical Officer—J. Mellor (on leave).

Microbiology Section—
Senior Research Officer—W. J. Scott, B.Agr.Sc.
Research Officer—M. R. J. Salton, B.Sc.Agr. (on leave).
Research Officer—W. G. Murrell, B.Sc.Agr.
Research Officer—B. T. Overell, M.Sc.
Technical Officer—P. R. Maguire.
Technical Officer—D. F. Ohye, Dip.Ind.Chem.

General Chemistry Section—
Senior Research Officer—F. E. Huelin, B.Sc., Ph.D.
Research Officer—H. A. McKenzie, M.Sc. (on leave).
Research Officer—Mrs. A. R. Thompson, M.Sc.
Technical Officer—R. A. Gallop, A.S.T.C.
Technical Officer—F. S. Shenstone, A.S.T.C.

Fruit Storage Section—
Principal Research Officer—R. N. Robertson, B.Sc., Ph.D.
Research Officer—E. G. Hall, B.Sc.Agr.
Research Officer—J. F. Turner, M.Sc.
Research Officer—H. S. McKee, B.A., D.Phil.
Research Officer—Miss M. Wilkins, B.Sc.
Research Officer—Miss J. A. Fraser, B.Sc.

Canning and Fruit Products Section—
Senior Research Officer—L. J. Lynch, B.Agr.Sc.
Senior Research Officer—J. F. Kefford, M.Sc.
Research Officer—R. S. Mitchell, M.Sc.Agr.
Research Officer—B. V. Chandler, B.Sc.
Technical Officer—P. C. O. Thompson, A.S.T.C.
Technical Officer—G. F. Greethead, A.S.T.C.

Dried Foods Section—
Senior Research Officer—Miss T. M. Reynolds, M.Sc., D.Phil.
Senior Research Officer—A. Howard, M.Sc.
Research Officer—A. R. Prater, B.Sc.Agr.
Research Officer—D. McG. McBean, B.Sc.
Research Officer—J. Shipton, B.Sc.Agr.

Fish Investigations—
Senior Research Officer—W. A. Empey, B.V.Sc.
Technical Officer—R. Allan.
Technical Officer—K. W. Anderson, A.M.T.C.

Meat Investigations (at Brisbane Abattoir)—
Senior Research Officer—A. R. Riddle, A.B., M.S.
Technical Officer—H. A. McDonald, Dip.Ind.Chem.
Technical Officer—N. T. Russell, Dip.Ind.Chem.

At Australia House, London—
Senior Research Officer—N. E. Holmes, B.E.E., M.Mech.E. (seconded).

(*k*) *Division of Fisheries.*

(Head-quarters: Cronulla, New South Wales.)

At Head-quarters—
Chief—H. Thompson, M.A., D.Sc.
Technical Secretary—Mrs. L. M. Willings, B.A.
Senior Research Officer (bacteriologist)—E. J. Ferguson Wood, B.A., M.Sc.
Research Officer (chemist and hydrologist)—D. J. Rochford, B.Sc.
Research Officer (biologist)—I. S. R. Munro, M.Sc.
Research Officer (biologist)—W. S. Fairbridge, M.Sc.
Research Officer (ichthyologist)—A. A. Rapson, M.Sc.
Research Officer (biologist)—G. S. Grace, B.Sc.
Research Officer (planktologist)—Miss P. Kott, M.Sc.
Marine Superintendent — Commander R. H. Thornton.
Senior Technical Officer (laboratory)—A. Proctor.
Gear Officer—A. Temple.
Clerk—T. A. Lewis.

At Melbourne—
Research Officer (biologist)—M. Blackburn, M.Sc.
Technical Officer (biologist)—P. E. Gartner, B.Sc.

At Perth—
Senior Principal Research Officer (officer-in-charge)—G. W. Rayner, M.Sc.
Senior Research Officer (biologist)—D. L. Serventy, B.Sc., Ph.D.
Research Officer (chemist and hydrologist)—R. S. Spencer, B.Sc.
Research Officer (biologist)—W. B. Malcolm, B.Sc.
Technical Officer—K. Sheard.
Technical Officer (sea-going)—B. Shipway.
Clerk—W. B. Gibson.

At Hobart—
Senior Research Officer (biologist)—A. G. Nicholls, B.Sc., Ph.D.
Research Officer (biologist)—A. M. Olsen, M.Sc.

At Dunwich, Queensland—
Research Officer (biologist)—J. M. Thomson, M.Sc.

At Thursday Island, Queensland—
Research Officer (biologist)—J. S. Hynd, B.Sc.

(*l*) *Australian National Standards Laboratory.*

(The services shown hereunder are common to the Divisions of Metrology, Electrotechnology and Physics, housed in the Laboratory.)

Clerical—
Chief Clerk—R. F. Williams.
Accountant—W. J. Gillespie, A.F.I.A., A.C.I.S.

Drawing Office—
Chief Draughtsman—C. Williamson.

Library—
Librarian—Miss M. Barnard, B.A.
Librarian—Miss M. McKechnie, B.A.
Librarian—Miss J. M. Cook.
Assistant Librarian—Miss E. M. Brown, M.A.
Assistant Librarian—Miss J. M. Hazlitt, B.A.
Assistant Librarian—Miss D. O. Haslam.

Workshops—
Works Supervisor—J. M. Hanna.

(*m*) *Division of Metrology.*

(Head-quarters: National Standards Laboratory at University of Sydney.)

Chief—N. A. Esserman, B.Sc., F.Inst.P., A.M.I.E. (Aust.).
Technical Secretary—N. H. Winters, B.E., A.M.I.E. (Aust.).
Senior Research Officer—P. M. Gilet, B.Sc., B.E., F.Inst.P., A.M.I.E.(Aust.).
Senior Research Officer—H. J. Ritter, Dr.rer.nat.-math.
Senior Research Officer—G. A. Bell, B.Sc., A.Inst.P.
Research Officer—C. F. Bruce, M.Sc., A.Inst.P.
Research Officer—H. A. Ross, A.S.T.C., A.M.I.E. (Aust.).
Research Officer—J. A. Macinante, B.E.
Research Officer—R. H. Furniss, A.S.T.C., A.M.I.E. (Aust.).
Research Officer—E. E. Adderley, B.Sc. (seconded to Division of Radiophysics).
Research Officer—W. A. F. Cuninghame, B.E.
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Research Officer—Miss P. M. Yelland.
Research Officer—R. J. Ellis, B.E.
Research Officer—J. Waldersee, B.Sc.
Research Officer—Miss M. M. Douglas, B.Sc.
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Technical Officer—D. H. Fox.
Technical Officer—G. W. Gore, A.S.T.C.
Technical Officer—W. Dollar, A.S.T.C.
Technical Officer—O. Pain.

(*n*) *Division of Electrotechnology.*

(Head-quarters: National Standards Laboratory at University of Sydney.)

Acting Chief—D. M. Myers, B.Sc., D.Sc.Eng.
Technical Secretary—R. C. Richardson, B.E.
Senior Research Officer—F. J. Lehany, M.Sc.
Senior Research Officer—L. G. Dobbie, M.E.

Senior Research Officer—W. K. Clothier, B.Sc., M.E.
Senior Research Officer—R. J. Meakins, B.Sc., Ph.D.
Senior Research Officer—A. M. Thompson, B.Sc.
Senior Research Officer—R. A. Sack, B.Sc., Ph.D.
Research Officer—B. V. Hamon, B.Sc., B.E.
Research Officer—D. L. Hollway, B.E.E., M.Eng.Sc.
Research Officer—L. Medina, Dipl.Eng.
Research Officer—R. K. Oliver, B.E.
Research Officer—J. S. Dryden, M.Sc.
Research Officer—G. J. A. Cassidy, B.E.E.
Research Officer—H. W. Stokes, B.Ec.
Research Officer—P. G. Walker, B.Sc.
Research Officer—T. M. Palmer, Dipl.F.H.
Research Officer—H. K. Welsh, M.Sc.
Research Officer—Miss J. W. Mulley, A.S.T.C.
Senior Technical Officer—L. M. Mandl, Dipl.Ing., A.S.T.C.
Technical Officer—F. C. Brown, A.S.T.C.
Technical Officer—E. G. Filby.
Technical Officer—R. W. Archer, A.S.T.C.
Technical Officer—H. A. Smith.
Technical Officer—H. Bairnsfather.
Technical Officer—E. Cowcher, A.S.T.C.
Technical Officer—R. L. Gregory, A.S.T.C.

(o) *Division of Physics.*

(Head-quarters: National Standards Laboratory at University of Sydney.)

Administration—
Chief—G. H. Briggs, D.Sc., Ph.D.
Technical Secretary—D. S. Woodward.

Heat—
Senior Research Officer—A. F. A. Harper, M.Sc.
Research Officer—W. R. G. Kemp, B.Sc.
Research Officer—W. A. Caw, B.Sc.
Research Officer—Miss R. Scott, B.Sc.
Research Officer—N. H. Westwood, B.Sc.
Technical Officer—J. H. Bestford, B.Sc.
Technical Officer—J. K. Braithwaite, A.M.T.C.
Technical Officer—J. W. W. Smyth.

Light—
Senior Research Officer—R. G. Giovanelli, D.Sc.
Research Officer—W. H. Steel, B.A., B.Sc.
Research Officer—J. W. Pearce, B.Sc.
Research Officer—K. A. B. Wright, B.Sc.
Research Officer—G. H. Godfrey, M.A., B.Sc. (part-time).
Research Officer—H. F. Pollard, M.Sc. (part-time).
Technical Officer—V. R. Schaefer.

Solar Physics—
Senior Research Officer—R. G. Giovanelli, D.Sc.

Wool Research—
Research Officer—Mrs. K. R. Makinson, B.A.
Technical Officer—Miss J. Griffith, A.S.T.C.

Electrical Standards—
Research Officer—Miss R. Scott, B.Sc.

Technical Services—
Technical Officer—J. E. Thompson.

Officers Abroad—
Research Officer—W. I. B. Smith, B.Sc.
Research Officer—J. K. Mackenzie, B.A., B.Sc.
Research Officer—R. G. Wylie, M.Sc.

(p) *Division of Industrial Chemistry.*

(Head-quarters: Lorimer-street, Fishermen's Bend, Melbourne; Postal Address: Box 4331, G.P.O., Melbourne.)

Administration—
Chief—I. W. Wark, D.Sc., Ph.D.
Divisional Secretary—L. Lewis, B.Met.E.
Assistant Secretary—A. E. Scott, M.Sc.

Minerals Utilization Section—
Senior Principal Research Officer—R. G. Thomas, B.Sc.
Senior Research Officer—A. Walkley, B.A., B.Sc., Ph.D.
Senior Research Officer—A. W. Wylie, M.Sc., Ph.D.
Research Officer—P. Dixon, M.Sc.
Research Officer—F. K. McTaggart, M.Sc.
Research Officer—T. R. Scott, D.Sc., B.Ed. (abroad).
Research Officer—F. R. Hartley, M.Sc.
Research Officer—A. D. Wadsley, M.Sc.
Research Officer—R. C. Croft, M.Sc.
Research Officer—I. C. Kraitzer.
Research Officer—E. S. Pilkington, A.S.T.C.
Research Officer—I. E. Newnham, M.Sc.
Research Officer—J. D. Hayton, B.Sc. (at S.A. School of Mines, Adelaide).
Technical Officer—H. R. Skewes.

Cement and Ceramics Section—
Senior Principal Research Officer—A. R. Alderman, D.Sc., Ph.D.
Senior Research Officer—W. O. Williamson, B.Sc., Ph.D., A.R.I.C.
Research Officer—A. J. Gaskin, M.Sc. (part-time).
Research Officer—R. H. Jones, B.Sc.
Research Officer—H. E. Vivian, B.Sc. Agr. (abroad).
Research Officer—S. M. Brisbane, B.A., A.M.T.C.
Research Officer—E. R. Segnit, M.Sc. (on study leave).
Research Officer—C. E. S. Davis, B.Sc.
Research Officer—H. R. Samson, M.Sc.
Research Officer—K. M. Alexander, M.Sc., Ph.D.
Research Officer—H. Ellerton (at Bonython Research Laboratory, S.A. School of Mines, Adelaide).
Senior Technical Officer—J. Coutts, A.M.T.C.
Technical Officer—Miss B. C. Terrell, B.Sc.
Technical Officer—J. H. Weymouth, B.Sc.

Foundry Sands Section—
Research Officer—H. A. Stephens, B.Sc.
Technical Officer—G. V. Cullen, Dipl.Met., Dipl.-Chem. Eng.
Technical Officer—J. E. Harper, A.M.T.C. (on study leave).

Physical Chemistry Section—
Principal Research Officer—K. L. Sutherland, D.Sc. (abroad) (part-time).
Research Officer—W. E. Ewers, M.Sc.
Research Officer—Miss A. McV. Lowen, Ph.D., B.Sc.
Research Officer—W. W. Mansfield, B.Sc.
Research Officer—K. F. Lorking, M.Sc.
Technical Officer—L. F. Evans, D.S.M.B.
Technical Officer—H. F. A. Hergt, A.M.T.C.

Chemical Physics Section—
Senior Principal Research Officer—A. L. G. Rees, D.Sc., Ph.D.
Senior Research Officer—E. H. Mercer, B.Sc., Ph.D.
Research Officer—A. Walsh, M.Sc.Tech.
Research Officer—A. McL. Mathieson, B.Sc., Ph.D.
Research Officer—J. L. Farrant, M.Sc. (abroad).
Research Officer—D. Davies, B.Sc.
Research Officer—J. M. Cowley, M.Sc. (abroad).
Research Officer—J. D. Morrison, B.Sc., Ph.D.
Research Officer—J. B. Willis, M.Sc., Ph.D.
Research Officer—G. R. Hercus, M.Sc.
Research Officer—A. J. Hodge, B.Sc.
Research Officer—A. F. Moodie, B.Sc.
Research Officer—J. P. Shelton, M.Sc., Dip. Appl. Chem.
Research Officer—C. Billington, B.A.
Research Officer—A. G. Pulford, B.Sc.
Senior Technical Officer—W. G. Jones.
Technical Officer—Miss R. J. Beckett, B.Sc.

Technical Officer—S. E. Powell.
Technical Officer—G. F. H. Box.
Technical Officer—F. B. Williams.
Draughtsman—C. R. Johnstone.

Organic Section—

Senior Principal Research Officer—H. H. Hatt, B.Sc., Ph.D., F.R.I.C.
Senior Research Officer—J. S. Fitzgerald, M.Sc., Ph.D.
Senior Research Officer—J. R. Price, M.Sc., D.Phil.
Research Officer—M. E. Winfield, M.Sc., Ph.D.
Research Officer—K. E. Murray, B.Sc., A.R.I.C.
Research Officer—R. G. Curtis, M.Sc., D.I.C.
Research Officer—R. J. L. Martin, M.Sc., Ph.D.
Research Officer—N. C. Hancox, M.Sc.
Research Officer—L. K. Dalton, A.S.T.C.
Research Officer—R. B. Bradbury, B.Sc.Agr., D.B.S.M.
Research Officer—W. D. Crow, M.Sc.
Research Officer—P. H. A. Strasser, M.Sc.
Research Officer—L. J. Drummond, M.Sc.
Technical Officer—W. J. Troyhan, A.M.T.C.
Technical Officer—R. Schonfeld, B.Sc.

Biochemistry Section—

Principal Research Officer—F. G. Lennox, D.Sc.
Research Officer—W. J. Ellis, A.S.T.C. (seconded).
Research Officer—W. G. Crewther, M.Sc.
Research Officer—Miss M. E. Maxwell, M.Sc.
Research Officer—J. M. Gillespie, M.Sc. (on study leave).
Research Officer—H. Lindley, B.A., Ph.D.
Research Officer—S. J. Leach, B.Sc.Tech., Ph.D.
Research Officer—E. F. Woods, M.Sc., A.M.T.C.
Research Officer—D. H. Simmonds, M.Sc.

Chemical Engineering Section—

Principal Research Officer—D. R. Zeidler, M.Sc.
Research Officer—I. Brown, B.Sc.
Research Officer—R. W. Urie, B.Sc., S.M.
Research Officer—J. F. Pearse, B.Sc., Ph.D., D.I.C.
Research Officer—B. W. Wilson, M.Sc.
Research Officer—B. S. Harrap, M.Sc., Ph.D.
Research Officer—D. E. Weiss, B.Sc.
Research Officer—M. L. Newman, B.Sc.App. (at Dept. of Chemical Engineering, University of Sydney).
Research Officer—K. Hall, B.Sc.
Technical Officer—J. L. Clay, A.M.T.C.
Technical Officer—J. B. Ross, B.Sc., A.M.T.C.
Technical Officer—D. H. Trethewey, A.M.T.C. (abroad).
Technical Officer—L. R. Bull, Dip.Mech.Eng.
Technical Officer—A. Ewald, B.Sc.
Technical Officer—K. A. Ophel.
Technical Officer—E. F. Symons, A.M.T.C.
Technical Officer—E. M. Jenkins, A.M.T.C.
Sectional Draughtsman—C. Simpson.
Draughtsman—J. Hession.

At University of Western Australia—

Alunite Investigations—

Research Officer—D. F. A. Koch, B.Sc.

At Canberra, Division of Entomology—

Research Officer—R. H. Hackman, M.Sc., Ph.D. (seconded).

At Sydney, Division of Electrotechnology—

Senior Research Officer—R. J. Meakins, B.Sc., Ph.D. (seconded).
Research Officer—Miss J. Mulley, A.S.T.C. (seconded).
Research Officer—H. K. Welsh, B.Sc. (seconded).

Photography—

Technical Officer—F. D. Lugton.

Library—

Librarian—Miss B. M. Brown, B.Sc.

(*q*) *Division of Radiophysics.*

(Head-quarters: At University of Sydney.)

Chief—E. G. Bowen, O.B.E., M.Sc., Ph.D.
Technical Secretary—A. J. Higgs, B.Sc.

Research—

Senior Principal Research Officer—J. L. Pawsey, M.Sc., Ph.D.

Radio Astronomy—

Principal Research Officer—J. H. Piddington, M.Sc., B.E., Ph.D.
Senior Research Officer—L. L. McCready, B.Sc., B.E.
Senior Research Officer—W. N. Christiansen, M.Sc.
Senior Research Officer—F. J. Kerr, M.Sc.
Senior Research Officer—H. C. Minnett, B.Sc., B.E.
Research Officer—Miss R. Payne-Scott, M.Sc.
Research Officer—A. B. Thomas, B.A.
Research Officer—B. Y. Mills, B.Sc., B.E.
Research Officer—S. F. Smerd, B.Sc.
Research Officer—J. G. Bolton, B.A.
Research Officer—D. E. Yabsley, B.Sc., B.E.
Research Officer—C. A. Shain, B.Sc.
Research Officer—K. C. Westfold, M.A., B.Sc.
Research Officer—J. P. Wild, B.A.
Technical Officer—C. S. Higgins.
Technical Officer—J. V. Hindman.
Technical Officer—K. R. McAlister, A.S.T.C.
Technical Officer—O. C. Turner.
Technical Officer—G. J. Stanley, A.S.T.C.
Technical Officer—J. D. Murray.
Technical Officer—A. G. Little.
Technical Officer—Miss M. C. Clarke, A.S.T.C.

Vacuum Physics—

Research Officer—N. R. Labrum, B.Sc.
Research Officer—E. K. Bigg, M.Sc.
Technical Officer—F. C. James.

Mathematical Physics—

Senior Research Officer—T. Pearcey, B.Sc.
Senior Research Officer—M. Beard, B.Sc., B.E.
Research Officer—R. D. Ryan, B.Sc., B.E.
Research Officer—Miss M. A. Adamson, B.A., Dip.Ed.
Technical Officer—F. C. Tonking, A.S.T.C.
Technical Officer—H. Harrant.

Meteorological Physics—

Senior Research Officer—P. Squires, M.A.
Senior Research Officer—J. Warner, B.Sc., B.E.
Research Officer—E. J. Smith, M.B.E., B.Sc. (Eng.).
Research Officer—Mrs. B. Smith, B.Sc.
Technical Officer—D. C. Dunn.
Technical Officer—K. Davidson.
Technical Officer—K. J. Heffernan.
Technical Officer—S. A. Pett.

Applied Research—

Principal Research Officer—V. D. Burgmann, B.Sc., B.E.

Radio Meteorology—

Research Officer—B. F. C. Cooper, B.Sc., B.E.
Research Officer—H. N. Edwardes, B.Sc., B.E.
Research Officer—H. L. Humphries, B.Sc., B.E.
Senior Technical Officer—G. T. Miles.
Technical Officer—T. D. Newnham.
Technical Officer—P. T. Hedges, A.S.T.C.
Technical Officer—R. C. Baker.
Technical Officer—L. F. Clague.
Technical Officer—N. C. Thorndike.
Technical Officer—C. F. Attwood.

Radio Navigation—

Research Officer—J. G. Downes, B.Sc.
Research Officer—E. B. Mulholland, B.Sc., B.E.
Research Officer—R. B. Coulson, B.Sc., B.E.
Research Officer—R. S. Styles, B.Sc., B.E.
Technical Officer—G. A. Wells, A.S.T.C.

Technical Officer—F. W. Campbell.
Technical Officer—K. V. Sheridan.
Technical Officer—R. E. Oldfield, A.S.T.C.
Technical Officer—J. Algie.

Measurements and Standards—
Research Officer—G. A. Day.

Engineering Services—
Assistant Technical Secretary—J. P. Eagles.
Chief Draughtsman—F. M. Carter.
Works Supervisor—H. Byers.

Photographic—
Technical Officer—R. S. B. Millett.
Technical Officer—A. J. A. Tolliday.

Officers Abroad—
Research Officer—Miss J. M. Freeman, M.Sc.
Research Officer—R. N. Bracewell, B.Sc., B.E.
Research Officer—J. S. Gooden, B.Sc.
Research Officer—T. R. Kaiser, M.Sc.
Research Officer—F. Gardner, B.Sc., B.E.

(*r*) DIVISION OF TRIBOPHYSICS.

(Head-quarters: At University of Melbourne.)

Acting Chief—W. Boas, D.Ing., M.Sc.
Research Officer—T. V. Krok, B.E.
Research Officer—M. F. R. Mulcahy, D.Phil., M.Sc., A.G.Inst.Tech.
Research Officer—A. J. W. Moore, Ph.D., B.Sc.
Research Officer—E. B. Greenhill, Ph.D., M.Sc.
Research Officer—R. G. Vines, M.Sc. (abroad).
Research Officer—D. Michell, B.E.E.
Research Officer—M. E. Hargreaves, B.Met.E. (abroad).
Research Officer—E. R. Ballantyne, B.Sc.
Research Officer—L. M. Clarebrough, B.Met.E., M.Eng.Sc.
Research Officer—A. J. Davis, B.Eng.
Research Officer—Miss M. J. Newing, B.Sc. (abroad).
Research Officer—J. F. Nicholas, B.Sc.
Research Officer—G. J. Ogilvie, B.Met.E., M.Eng.Sc.
Research Officer—J. V. Sanders, B.Sc. (abroad).
Research Officer—J. A. Spink, B.Sc.
Research Officer—G. W. West, B.E.E., B.Sc.
Research Officer—W. R. Flower, B.Sc.
Technical Officer—F. H. Hay.
Technical Officer—D. S. Kemsley, B.Sc., F.M.T.C.
Technical Officer—R. G. Sherwood, A.M.T.C.
Technical Officer—G. R. Berger, F.M.T.C.
Technical Officer—J. W. P. Nicholls.
Part-time Officer—P. J. Fensham, B.Sc.
Part-time Officer—I. C. Watt, B.Sc.
Goldsmith Dominion (Travelling) Scholar—T. Broom, B.A.

(*s*) BUILDING RESEARCH SECTION.

(Head-quarters: Graham-road, Highett, Victoria.)

Administration—
Officer-in-Charge — Ian Langlands, M.Mech.E., B.E.E.
Technical Secretary—W. F. Evans, B.Sc.

Information and Library—
Senior Research Officer—J. R. Barned, B.Sc.
Research Officer—R. C. McTaggart, B.Sc.
Research Officer—Mrs. C. M. Petrie, M.A., Ph.D. (part-time).
Librarian—Miss S. A. Hammill.

Mechanical and Physical Testing Laboratory—
Research Officer—P. H. Sulzberger, B.Sc.
Research Officer—A. J. Wilkins, B.E.
Research Officer—R. E. Lewis, B.Sc.

Concrete Investigations—
Senior Principal Research Officer—A. R. Alderman, D.Sc., Ph.D. (part-time).
Research Officer—W. H. Taylor, M.C.E.
Research Officer—G. M. Bruere, M.Sc.
Technical Officer—E. H. Mattison.

Masonry Investigations—
Senior Research Officer—J. S. Hosking, M.Sc., Ph.D.
Senior Research Officer—H. V. Hueber, Dr.Phil.
Research Officer—D. J. David, B.Sc.
Technical Officer—A. R. Carthew, B.Sc.
Technical Officer—A. E. Holland.

Surfacing Materials Investigations—
Senior Research Officer—E. H. Waters, M.Sc.
Research Officer—J. M. Hutson, M.A., B.Sc.
Research Officer—J. E. Bright, B.Sc.
Technical Officer—D. A. Powell, B.Sc.
Technical Officer—M. Shnider, F.M.T.C.
Technical Officer—I. McLachlan.

Building Boards and Insulating Materials Investigations—
Research Officer—R. W. Muncey, B.E.E.
Research Officer—P. E. Hands, B.Sc.
Research Officer—T. S. Holden, B.Sc.
Technical Officer—A. W. Wilson, Dip.Mech.Eng., Dip.Elec.Eng.
Technical Officer—J. J. Russell.
Technical Officer—P. E. Broughton, Dip.Mech.Eng., Dip.Elec.Eng.

Organic Materials Investigations—
Research Officer—B. M. Holmes, M.Sc.
Research Officer—J. J. Greenlands, B.Sc.(App.)
Technical Officer—N. G. Brown, A.M.T.C.
Technical Officer—J. W. Spencer, B.Sc.

Drawing Office—
Sectional Draughtsman—G. T. Stephens, Dip.Mech. Eng., Dip.Elec.Eng.
Draughtsman—D. G. Howson.

(*t*) FLAX RESEARCH SECTION.

(Head-quarters: Graham Road, Highett, Victoria).
Officer-in-Charge—W. L. Greenhill, M.E.
Senior Research Officer—Miss J. F. Couchman, B.Sc.
Senior Research Officer—G. W. Lanigan, M.Sc.
Research Officer—A. M. Munro, M.A.
Research Officer—W. Shepherd, B.Sc., B.Agr.Sc.
Technical Officer—D. K. Haslam.
Technical Officer—M. Tisdall.
Technical Officer—W. G. Lewis, B.Sc., B.A.

(*u*) DAIRY RESEARCH SECTION.

(Head-quarters: Lorimer-street, Fishermen's Bend, Melbourne).
Officer-in-Charge—G. Loftus Hills, B.Agr.Sc.
Senior Research Officer—E. G. Pont, M.Sc.Agr.
Research Officer—J. Conochie, B.Sc.(Agric.).
Research Officer—A. J. Lawrence, B.Sc.
Research Office—D. A. Forss, M.Sc.

(*v*) SECTION OF MATHEMATICAL STATISTICS.

(Head-quarters: At University of Adelaide.)

At Sectional Head-quarters, Adelaide—
Officer-in-Charge—E. A. Cornish, M.Sc., B.Agr.Sc.
Research Officer—A. T. James, M.Sc.
Research Officer—R. Birtwistle, B.Sc.
Research Officer—G. G. Coote, B.A., B.Sc.
Research Officer—N. S. Stenhouse, B.Sc.
Research Officer—Miss J. E. Rogerson, B.Sc.
Sectional Secretary—Miss E. M. G. Goodale (on extended leave)—Mrs. D. B. Kempson.

At Division of Animal Health and Production, Sydney—
Research Officer—Miss H. A. Newton Turner, B.Arch.
Research Officer—G. E. Ferris, B.Sc.
Research Officer—Miss E. F. Foster, B.Sc.
Research Officer—Miss P. M. Ohlsson, B.Sc.

At Division of Forest Products, Melbourne—
Research Officer—E. J. Williams, B.Com.
Research Officer—R. T. Leslie, B.A., B.Sc.

At Division of Plant Industry, Canberra—
Senior Research Officer—G. A. McIntyre, B.Sc., Dip.Ed.

(*w*) Radio Research.

(Head-quarters: At Electrical Engineering Department, University of Sydney.)

At Canberra—
Senior Principal Research Officer—D. F. Martyn, D.Sc., Ph.D., A.R.C.Sc.
Technical Officer—R. O. Errey.

At Sydney—
Principal Research Officer—G. H. Munro, M.Sc.
Senior Research Officer—W. L. Price, B.Sc. (part time).
Research Officer—J. A. Harvey, B.Sc.
Research Officer—L. Heisler, B.Sc.
Research Officer—C. B. Kirkpatrick, M.Sc. (part time).
Technical Officer—Miss B. Hardwick, B.A.

(*x*) Section of Physical Metallurgy.

(Head-quarters: at University of Melbourne.)

Officer-in-Charge (honorary)—Professor J. N. Greenwood, D.Sc., M.Met.E. (on leave).
Acting Officer-in-Charge (honorary)—W. A. Wood, D.Sc.
Research Officer—H. W. Worner, M.Sc.
Research Officer—A. D. McQuillan, B.Sc.
Research Officer—R. C. Gifkins, B.Sc.

(*y*) Ore-dressing Investigations.

At University of Melbourne—
Officer-in-Charge—H. H. Dunkin, B.Met.E. (part-time).
Senior Research Officer—K. S. Blaskett, B.E.
Research Officer—S. B. Hudson.
Technical Officer—F. D. Drews.

At School of Mines, Kalgoorlie, Western Australia—
Officer-in-Charge—R. A. Hobson, B.Sc. (part-time).

(*z*) Mineragraphic Investigations.

Senior Principal Research Officer—F. L. Stillwell, D.Sc.
Senior Research Officer—A. B. Edwards, D.Sc., Ph.D.
Research Officer—G. Baker, M.Sc.

(*aa*) Meteorological Physics.

Officer-in-Charge—C. H. B. Priestley, M.A.
Senior Research Officer—W. C. Swinbank, B.Sc.
Senior Research Officer—E. L. Deacon, B.Sc.
Research Officer—R. W. James, M.Sc.
Research Officer—I. C. McIlroy, B.Sc.
Research Officer—R. M. Fry, B.Sc.
Senior Technical Officer—R. J. Taylor, B.Sc.
Technical Officer—I. S. Groodin, Dip.Mat.
Technical Officer—Mrs. R. I. Lee.

(*bb*) Tracer Elements.

Senior Research Officer—T. H. Oddie, D.Sc.
Research Officer—A. M. Downes, M.Sc.

(*cc*) Atomic Physics.

Research Officer—W. B. Lasich, M.Sc.
Research Officer—J. R. Prescott, B.Sc.

(*dd*) Wool Textile Research Section.

At Geelong—
Technical Secretary—N. A. Whiffen, F.S.T.C.
Senior Research Officer—M. Lipson, Ph.D.
Senior Research Officer—D. L. C. Jackson, B.Sc.
Research Officer—N. K. Boardman, M.Sc.
Assistant Librarian—Miss D. Norman.

At Maribyrnong—
Principal Research Officer—E. J. Drake.
Draughtsman—E. E. Slade.

At Sydney—
Senior Research Officer—M. R. Freney, B.Sc.

(*ee*) Oenological Research.

Senior Research Officer—J. C. M. Fornachon, M.Sc., B.Ag.Sc.
Research Officer—W. K. Joklik, M.Sc.

(*ff*) Coal Research Section.

Officer-in-Charge—H. R. Brown, B.Sc.Eng.
Technical Secretary—L. Taylor, B.Sc.(Min.Eng.).
Research Officer (micropetrology)—N. J. de Jersey, M.Sc., Ph.D., D.I.C.
Survey Officer—O. Morris.
Survey Officer—M. S. Burns.
Survey Officer—V. F. Hunt, A.S.M.B.

5. Publications.

The following papers have been published during the year:—

(*a*) *Division of Plant Industry.*

Bald, J. G. (1948).—The structure of plastids and other cytoplasmic bodies in fixed preparations of epidermal strips. *Aust. J. Sci. Res.* B 1: 452-7.

Bald, J. G. (1948).—The development of amoeboid inclusion bodies of tobacco mosaic virus. Ibid. 458-63.

Brock, R. D. (1948).—The nature of Fusarium wilt resistance in the tomato variety Pan America. *J. Aust. Inst. Agric. Sci.* 14: 78-81.

Donald, C. M., *and* Roe, R. (1949).—Australian sheep pastures. *Australian Woolgrowers' Hand-book* 1949.

Greenham, C. G. (1948).—A portable meter for soil moisture determination. *J. Coun. Sci. Industr. Res. Aust.* 21: 308.

Hutton, E. M. (1948).—Potato improvement in Australia. *J. Aust. Inst. Agric. Sci.* 14: 71-6.

Hutton, E. M. (1949).—Increasing the infectivity of spotted wilt virus. *J. Aust. Inst. Agric. Sci.* 15: 43-5.

Hutton, E. M. (1949).—Some factors affecting localized and systemic necrotic reactions to virus Y in the potato. *Aust. J. Sci. Res.* B 1: 416-38.

Hutton, E. M. (1949).—The separation of strains from a virus X complex by passage through potato seedlings. Ibid. 439-51.

Hutton, E. M., *and* Oldaker, C. E. W. (1949).—Rosette, a virus disease of the potato in Tasmania. *J. Aust. Inst. Agric. Sci.* 15: 25-32.

Hutton, E. M., *and* Peak, A. R. (1949).—Spotted wilt resistance in the tomato. Ibid. 32-7.

Roe, R., *and* Shaw, S. H. (1947).—Mintweed, *Salvia reflexa* Hornem. Present distribution and status in Australia. Counc. Sci. Industr. Res. Aust. Bull. No. 231.

Wark, D. C., *and* Giles, J. E. (1948).—Some studies in the growth of tomato plants and comparison of tomato varieties grown under irrigation. *J. Coun. Sci. Industr. Res. Aust.* 21: 99-115.

Wark, D. C. (1949).—The treatment of pea seed carrying bacterial blight. *J. Aust. Inst. Agric. Sci.* 15: 37-41.

Webb, L. J. (1948).—Alkaloids in Queensland *Cryptocarya* spp. *Aust. J. Sci.* 11: 26-7.

Webb, L. J., *et al.* (1948).—Alkaloids of the Australian Rutaceae. *Nature* 162: 223.

(b) *Division of Entomology.*

Carne, P. B. (1948).—Persistence of DDT in the soil. *Nature* 162 : 743.

Day, M. F. (1949).—The distribution of ascorbic acid in the tissues of insects. *Aust. J. Sci. Res.* B 2 (1) : 19-30.

Day, M. F. (1949).—The distribution of alkaline phosphatase in insects. Ibid. 31-41.

Gilmour, D. (1948).—Myosin and adenyl pyrophosphatase in insect muscle. *J. Biol. Chem.* 175 (1) : 477-8.

Greaves, T., *and* Venables, D. G. (1948).—The insecticidal control of cabbage pests: a summary of experimental results, 1944-48. *J. Coun. Sci. Industr. Res. Aust.* 21 (3) : 172-6.

Hackman, R. N., Pryor, M. G. M., *and* Todd, A. R. (1948).—The occurrence of phenolic substances in arthropods. *Biochem. J.* 43 (3) : 474-7.

Holdaway, F. G., *and* Gay, F. J. (1948).—Temperature studies of the habitat of *Eutermes exitiosus* with special reference to the temperatures within the mound. *Aust. J. Sci. Res.* B 1 (4) : 464-93.

Mackerras, M. J., *and* Mackerras, I. M. (1948).—Simuliidae (Diptera) from Queensland. *Aust. J. Sci. Res.* B 1 (2) : 231-70.

Nicholson, A. J. (1947).—Fluctuation of animal populations. Presidential Address Section D.—Zoology. *Rep. 26th Meeting A.N.Z.A.A.S.* : 134-47.

(c) *Division of Animal Health and Production.*

Austin, C. R. (1948).—Function of hyaluronidase in fertilization. *Nature* 162 : 63.

Austin, C. R., *and* Smiles, J.[*] (1948).—Phase-contrast microscopy in the study of fertilization and early development of the rat egg. *J. R. Micr. Soc.* 68 : 13.

Beck, A. B., Bennetts, H. W.,[†] *and* Harley, R. (1948).—Pathogenesis of "falling disease": studies on copper deficiency in cattle. *Aust. Vet. J.* 24 : 237-44.

Beck, A. B., *and* Sheard, K. (1949).—Copper and nickel content of the blood of the Western Australian marine crayfish (*Panulirus longipedes* Milne Edwards), and of seaweeds. *Aust. J. Exp. Biol. Med. Sci.* 27 : 307-12.

Campbell, A. D., *and* Rodwell, A. W. (1949).—Experimental investigation of calfhood vaccination with *Brucella abortus* Strain 19. Resistance of vaccinated calves against natural infection. *Aust. Vet. J.* 25 : 46-52.

Dick, A. T. (1948).—Histochemistry—A general review. *Aust. Chem. Inst. J. & Proc.* 15: 294-308.

Ferguson, K. A., Carter, H. B., *and* Hardy, M. H. (1949).—Studies of comparative fleece growth in sheep. 1. The quantitative nature of inherent differences in wool growth rate. *Aust. J. Sci. Res.* B 2 : 42-81.

Gill, D. A. (1948).—Illness associated with lameness in sheep after dipping. *Aust. Vet. J.* 24: 297.

Gregory, T. S. (1949).—Studies on bovine tuberculosis in the Australian environment. 1. Tuberculins and their usage intradermally. Ibid. 25: 17-26.

Graham, N. P. H., *and* Scott, Marion T. (1948).—Observations on the control of some ectoparasites of sheep. 1. The use of arsenic, rotenone, sulphur, and phenol compounds for the control of the sheep ked (*Melophagus ovinus*) and the sheep body louse (*Damalinia ovis*). *J. Coun. Sci. Industr. Res. Aust.* 21: 252. 2. Progress report on the use of DDT and benzene hexachloride for the control of the sheep ked (*Melophagus ovinus*) and the sheep body louse (*Damalinia ovis*). Ibid. 21 : 266.

Gordon, H. McL. (1948).—The anthelmintic efficiency of phenothiazine sulphoxide against *Oesophagostomum columbianum* in sheep. *Aust. Vet. J.* 24: 335.

Gordon, H. McL. (1948).—Control of worm parasites of sheep. *Qd. Agric. J.* 67: 33.

Kelley, R. B. (1948).—Zebu-cross cattle in Northern Australia: observations in Queensland. *Progr. Rep. Coun. Sci. Industr. Res.* No. 6: 26.

Massey, V., *and* Rogers, W.P. (1949).—The tricarboxylic acid cycle in nematode parasites. *Nature* 163 : 909.

Murnane, D. (1949).—Results of tests with newer penicillin preparations, and of treatment of staphylococcal infections of the bovine udder with penicillin, sulphone, and sulphone plus penicillin. *Aust. Vet. J.* 25: 85-94.

Roberts, F. H. S. (1948).—Distribution and seasonal prevalence of Anopheline mosquitoes in North Queensland. *Proc. Roy. Soc. Qd.* 49: 93-100.

Rogers, W. P. (1948).—The integration of biological, chemical, and pharmacological investigation in the search for efficient anthelmintics. *Aust. Vet. J.* 24: 220.

Rogers, W. P. (1948).—The respiratory metabolism of parasitic nematodes. *Parasitology* 39: 105.

Rogers, W. P. (1949).—Aerobic metabolism in nematode parasites of the alimentary tract. *Nature,* 163: 879-880.

Rogers, W. P., *and* Lazarus, M. (1948).—Glycolysis and related phosphorus metabolism in parasitic nematodes. *Parasitology* 39 : 302.

Rogers, W. P., *and* Lazarus, M. (1948).—The uptake of radioactive phosphorus from host tissues and fluids by nematode parasites. Ibid. 39: 245.

Turner, A. W. (1948).—Influence of nutrition upon the immune response and upon resistance to infection. *Rep. 26th Meeting A.N.Z.A.A.S.* 252-65.

Whitlock, H. V. (1948).—Some modifications of the McMaster helminth egg counting technique and apparatus. *J. Coun. Sci. Industr. Res. Aust.* 21: 177.

Whitlock, H. V. (1948).—A method for staining small nematodes to facilitate worm counts. Ibid. 21: 181.

Whitten, W. K. (1948).—Inactivation of gonadotrophins. 2. Inactivation of pituitary and chorionic gonadotrophins by influenza virus and receptor-destroying enzyme. *Aust. J. Sci. Res.* B 1 : 388.

Whitten, W. K. (1949).—Enzyme inactivation of serum gonadotrophins. *Nature* 163: 534.

(d) *Division of Biochemistry and General Nutrition.*

Dawbarn, M. C. (1949).—The determination of thiamine in white bread by the thiochrome method. *Aust. J. Exp. Biol. Med. Sci.* 27 : 207.

Dawbarn, M. C. (1949).—The thiamine content of white bread in Adelaide. Ibid. 27: 215.

Dawbarn, M. C. (1949).—The effects of milling upon the nutritive value of wheaten flour and bread. *Nutr. Abstr. Rev.* 18 : 691.

Gray, F. V. (1948).—The asorption of volatile fatty acids from the rumen. II. The influence of pH on absorption. *J. Exp. Biol.* 25: 135.

Gray, F. V., *and* Pilgrim, A. F. (1948).—The microanalysis of mixtures of volatile fatty acids. *J. Coun. Sci. Industr. Res. Aust.* 21: 347.

Jarrett, I. G. (1948).—The production of rumen and abomasal fistulae in sheep. Ibid. 311.

Jarrett, I. G. (1948).—Continuous intravenous injection in sheep. Ibid. 316.

Marston, H. R. (1948).—The fermentation of cellulose *in vitro* by organisms from the rumen of sheep. *Biochem. J.* 42: 564.

Marston, H. R. (1948).—Nutritional factors involved in wool production by Merino sheep. I. The influence of fodder intake on the rate of wool growth. *Aust. J. Sci. Res.* B 1: 362.

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[*] National Institute for Medical Research, London.
[†] Department of Agriculture, Western Australia.

Marston, H. R., *and* Lee, H. J. (1948).—Nutritional factors involved in wool production by Merino sheep. II. The influence of copper deficiency on the rate of wool growth and on the nature of the fleece. Ibid. 376.

Riceman, D. S. (1948).—Mineral deficiency in plants on the soils of the Ninety-mile Plain in South Australia. II. Effect of zinc, copper, and phosphate on subterranean clover and lucerne grown on Laffer Sand, near Keith. Coun. Sci. Industr. Res. Aust. Bull. No. 234.

Riceman, D. S., *and* Powrie, J. K. (1948).—Mineral deficiency in plants on the soils of the Ninety-mile Plain in South Australia. III. Differences in the behaviour of the Dwalganup and later-flowering varieties of subterranean clover. *J. Aust. Inst. Agric. Sci.* 14: 138.

Riceman, D. S. (1949).—Mineral deficiency in plants on the soils of the Ninety-mile Plain in South Australia. IV. Effect of cover crops and phosphate on subterranean clover, lucerne, and Phalaris sown with zinc and copper on Laffer Sand, near Keith. Coun. Sci. Industr. Res. Aust. Bull. No. 249.

Riceman, D. S. (1948).—Mineral deficiency in plants on the soils of the Ninety-mile Plain in South Australia. V. Effect of growth and removal of a crop treated with zinc and copper upon pasture established subsequently on Laffer Sand, near Keith. *J. Coun. Sci. Industr. Res. Aust.* 21: 229.

Riceman, D. S. (1948).—Mineral deficiency in plants on the soils of the Ninety-mile Plain in South Australia. VI. Comparison of methods of establishment of mixed pasture sown with zinc and copper on Laffer Sand, near Keith. Ibid. 236.

Rodda, H. J., *in collaboration with* Todd, A. R., Kenner, G. W., *and* Baddiley, J. (1949).—The chemistry of the purines and pyrimidines (in "The Chemistry of Heterocyclic Compounds", Vol. 1. John Wiley & Sons).

Stephen, V. A. (1948).—Fluorimeter for estimation of small quantities of thiamine. *J. Coun. Sci. Industr. Res. Aust.* 21: 355.

(*e*) *Division of Soils.*

Northcote, K. H., *and* Tucker, B. M. (1949).—A soil survey of the Hundred of Seddon and part of the Hundred of MacGillivray, Kangaroo Island, South Australia. Coun. Sci. Industr. Res. Aust. Bull. No. 233.

Piper, C. S. (1947).—Trace elements in soils and plants. *Rep. 26th Meeting A.N.Z.A.A.S.*: 82.

Piper, C. S., *and* Beckwith, R. S. (1948).—A new method for determination of small amounts of molybdenum in plants. *J. Soc. Chem. Ind.* 67: 334.

Smith, R. (1948).—Soil types of the Margaret River District, Western Australia. *J. Agric. W. Aust.* (2nd series) 25: 426.

Smith, R. (1948).—A relationship between soil and topography in south-western Australia. *J. Aust. Inst. Agric. Sci.* 14: 15.

(*f*) *Division of Forest Products.*

Amos, G. L., *and* Dadswell, H. E. (1948).—Siliceous inclusions in wood in relation to marine borer resistance. *J. Coun. Sci. Industr. Res. Aust.* 21 (3): 190.

Chattaway, M. M. (1948).—The wood anatomy of the Proteaceae. *Aust. J. Sci. Res.* B 1 (3): 279-302.

Chattaway, M. M. (1948).—Note on the vascular tissue in the rays of *Banksia*. *J. Coun. Sci. Industr. Res. Aust.* 21 (4): 275-8.

Cohen, W. E. (1948).—Pulp and paper from Australian Eucalypts. *Unasylva* 2 (6): 309-15.

Cohen, W. E. (1948).—Performance and use of the Lampen mill in Australia. *Aust. Pulp and Paper Ind. Tech. Assn. Proc.* 2: 84-131.

Dadswell, H. E., *and* Ingle, H. D. (1948).—The anatomy of the timbers of the S.W. Pacific area. I. Anacardiaceae. *Aust. J. Sci. Res.* A 1 (4): 391-415.

Head, A. E. (1948).—The Australian furniture industry. *Aust. Forestry* 12 (2): 124-6.

Higgins, H. G., *and* Plomley, K. F. (1949).—Study of the rheological properties of rapidly thickening colloidal systems by means of the Stormer viscometer. *Nature* 163: 22.

Kloot, N. H. (1948).—Mechanical tests on small clear specimens of Queensland maple. *J. Coun. Sci. Industr. Res. Aust.* 21 (4): 279-97.

Turnbull, R. F. (1948).—Handling and preparation of wood at pulp mills. *Aust. Pulp and Paper Ind. Tech. Assn. Proc.* 2: 42-80.

Turnbull, R. F. (1948).—Integration of pulpwood and sawn timber production. *Aust. Forestry* 12 (2): 88-111.

Wardrop, A. B. (1948).—Fine structure of cell walls in fresh plant tissues. (With R. D. Preston *and* E. Nicolai.) *Nature* 162: 957-60.

Wardrop, A. B. (1949).—The influence of pressure on the cell wall organization of conifer tracheids. *Leeds Philos. Soc. Proc.* 5 (2): 128-35.

Wright, G. W. (1948).—Sawmill study and forest management. *Aust. Forestry* 12 (1): 16-26.

(*g*) *Division of Food Preservation and Transport.*

Briggs, G. E., and Robertson, R. N. (1948).—Diffusion and absorption in discs of plant tissue. *New Phytol.* 47: 265.

Hicks, E. W. (1948).—Refrigeration in fishing vessels. *Fisheries Newsletter* 7 (4): 14.

Hicks, E. W. (1948).—Refrigerated transport: an address given to the N.S.W. Division of the Australian Institute of Refrigeration. *Refrig. J.* 2: 824.

Huelin, F. E., *and* Stephens, I. Myee (1948).—The copper-catalysed oxidation of ascorbic acid in fruit and vegetable suspensions. *Aust. J. Sci. Res.* B 1: 50.

Huelin, F. E., *and* Stephens, I. Myee (1948).—The enzyme-catalysed oxidation of ascorbic acid in fruit and vegetable suspensions. *Aust. J. Sci. Res.* B 1: 58.

Kefford, J. F. (1948).—Refrigeration in the fruit juice industry. *Refrig. J.* 2: 658.

McKee, H. S. (1949).—Review of recent work on nitrogen metabolism. *New Phytol.* 48: 1.

McKenzie, Hugh A. (1948).—Polarographic current time curves. *J. Amer. Chem. Soc.* 70: 3147.

McKenzie, Hugh A. (1948).—Effect of the viscosity of the medium on polarographic diffusion currents. *J. Coun. Sci. Industr. Res. Aust.* 21: 210.

(*h*) *Division of Fisheries.*

Blackburn, M. (1948).—Notes on some parasitic Actinian larvae and one of their host Medusae in Australian waters. *J. Coun. Sci. Industr. Res. Aust.* 21 (3): 183-9.

Fairbridge, W. S. (1948).—The effect of the war on the east Australian trawl fishery. Ibid. 21 (2): 75-98.

Humphrey, G. (1947).—The succinoxidase system in oyster muscle. *J. Exp. Biol.* 24: 352-60.

May, Valerie (1948).—Studies of Australian marine algae. IV. *Proc. Linn. Soc. N.S.W.* 73: 293-7.

Munro, I. S. R. (1948).—*Sparidentex hasta* (Cuvier and Valenciennes) a new name for *Chrysophrya cuvieri* Day. *Copeia* 1948 (4): 275-80.

Munro, I. S. R. (1949).—Revision of the Australian silver breams *Acanthopagrus* Peters and *Austrosparus* Smith. *Mem. Qd. Mus.* 12 (4): 182-223.

Thompson, H. (1947).—Fish Welfare. *Pap. Proc. Roy. Soc. Tas.* 1947: 1-19.

(*i*) *Division of Metrology.*

Bruce, C. F. (1949).—Frictional forces in dial gauges. *Engineering* 167 : February 25.

(*j*) *Division of Electrotechnology.*

Meakins, R. J. (1948).—Note on the treatment of textile materials with methyl silicon amine to give improved resistance to the penetration of moisture. *J. Coun. Sci. Industr. Res. Aust.* 21 : 222.

Meakins, R. J. (1948).—The dielectric relaxation times of solid solutions of aliphatic long-chain esters and ketones in paraffin wax and n-hexacosane. *Nature* 162 : 994.

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Thompson, A. M. (1949).—A falling-sphere viscometer for use with opaque liquids. *J. Sci. Instrum.* 26 (3).

(*k*) *Division of Physics.*

Giovanelli, R. G. (1947).—Magnetic and electric phenomena in the Sun's atmosphere associated with sunspots. *Mon. Not. R. Astr. Soc.* 107 (4) : 338.

Giovanelli, R. G. (1948).—Chromospheric flares. Ibid. 108 (2) : 163.

Giovanelli, R. G. (1948).—Hydrogen atmospheres in the absence of thermodynamic equilibrium, I.-IV. *Aust. J. Sci. Res.* A 1 : 275, 289, 305, 360.

Giovanelli, R. G. (1949).—Electron energies resulting from an electric field in a highly ionized gas. *Phil. Mag.* 40 : 206.

Makinson, K. R. (1948).—On the cause of the frictional difference of the wool fibre. *Trans. Faraday Soc.* 305 (5) : 279.

(*l*) *Division of Industrial Chemistry.*

Bayliss, H. S., Cowley, J. M., Farrant, J. L., *and* Miles, G. L. (1948).—The thermal decomposition of synthetic and natural alunite; an investigation by X-ray diffraction, electron diffraction, and electron microscope methods. *Aust. J. Sci. Res.* A 1 : 343.

Cullen, G. V., *and* Marshall, J. E. (1948).—An automatic machine for determining clay substance in moulding sands. *J. Coun. Sci. Industr. Res. Aust.* 21 : 197.

Curtis, R. G., *and* Hatt, H. H. (1948).—Equilibria in furfural-water systems under increased pressure and the influence of added salts upon the mutual solubilities of furfural and water. *Aust. J. Sci. Res.* A 1 : 213.

Draper, M. H., *and* Hodge, A. J. (1949).—Sub-microscopic localization of minerals in the skeletal muscle by internal microincineration with the electron microscope. *Nature* 163 : 576.

Ellis, W. J. (1948).—Method for obtaining wool roots for histochemical examination. Ibid. 162 : 957.

Farrant, J. L., *and* Hodge, A. J. (1948).—An interferometric method for the calibration of electron microscope magnifications. *J. Appl. Phys.* 19 : 840.

Farrant, J. L., *and* O'Connor, J. L. (1949).—The elementary bodies of *Varicella* and *Herpes zoster*. *Nature* 163 : 260.

Greenaway, H. T. (1947).—The surface tension and density of lead-antimony and cadmium-antimony alloys. *J. Inst. Met.* 74 : 133.

Hatt, H. H. (1949).—Fatty acids. *J. Proc. Aust. Chem. Inst.* 15 : 309.

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